



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

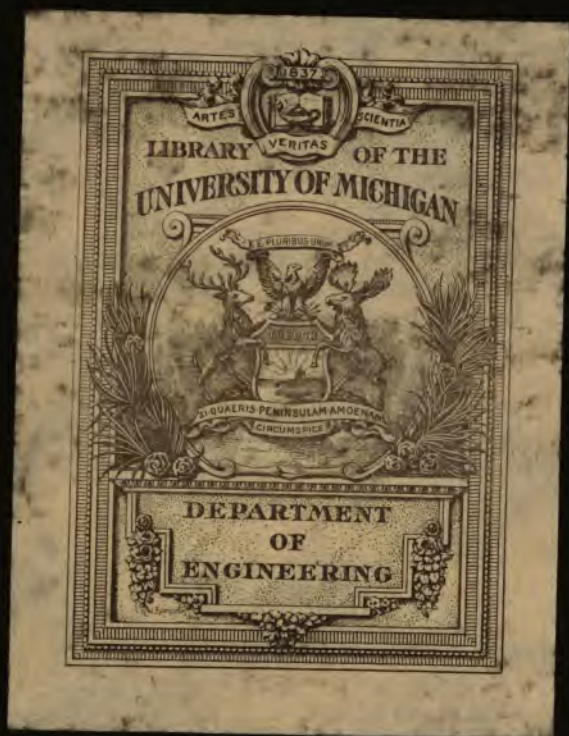
Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

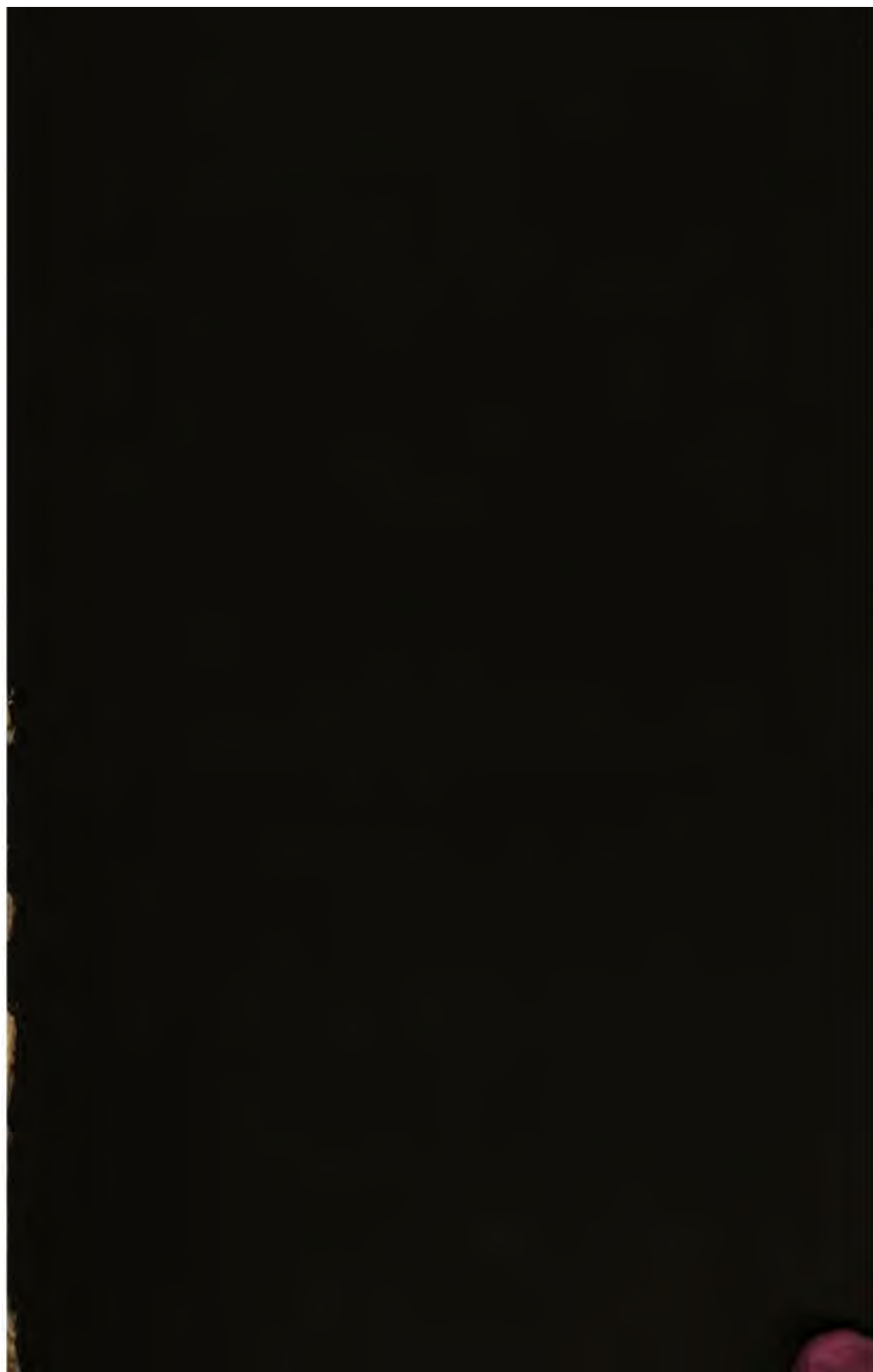
We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

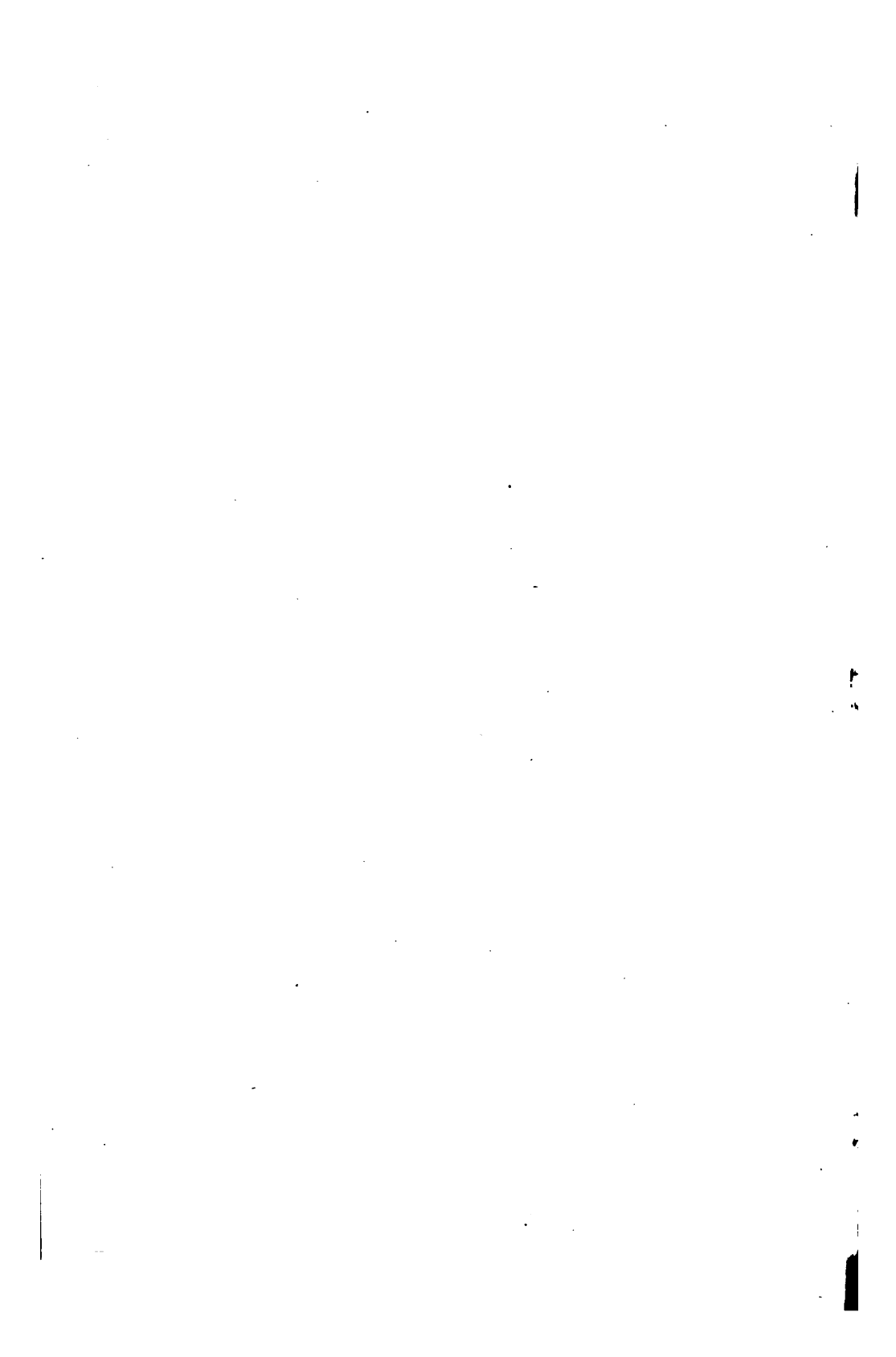
About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>





TJ
547
H97
1902
cop. 2



VALVES AND VALVE-GEARING.

STANDARD WORKS FOR ENGINEERS.

By Prof. JAMIESON, M.Inst.C.E., M.Inst.E.E., F.R.S.E.,

Glasgow and West of Scotland Technical College.

In Crown 8vo, Cloth. With many Illustrations and Examination Papers.

Jamieson's Steam and Steam Engines. With over 200 Illustrations, Folding Plates, and Examination Papers. *Thirteenth Edition.* 8/6.

"The BEST BOOK yet published for Students."—*Engineer.*

Jamieson's Elementary Manual of Steam and the Steam Engine. *Ninth Edition, Revised and Enlarged.* 3/6.

"Quite the RIGHT SORT of book."—*Engineer.*

Jamieson's Magnetism and Electricity. With 246 Illustrations and Examination Papers. *Fifth Edition, Revised.* 8/6.

"A THOROUGHLY TRUSTWORTHY TEXT-BOOK."—*Nature.*

Jamieson's Applied Mechanics (An Advanced Text-book on). Vol. I.—Comprising Part I.: The Principle of Work and its Applications: Part II.: Gearing. *Third Edition.* Price 7/6. Vol. II.—Motion and Energy; Strength of Materials; Statics, Hydraulics, &c. *Second Edition.* 8/6.

"FULLY MAINTAINS the reputation of the author—more we cannot say."—*Pract. Engineer.*

Jamieson's Applied Mechanics (An Introductory Manual). *Fifth Edition, Revised.* 3/6.

"Nothing is taken for granted. . . . The work has VERY HIGH QUALITIES, which may be condensed into the one word—'CLEAR.'"—*Science and Art.*

Engineering Drawing and Design. By S. H. WELLS, W.H.Sc., A.M.I.C.E., A.M.I.Mech.E., Principal and Head of the Engineering Department, Battersea Polytechnic Institute. In Two Parts. Sold separately. *Third Edition.*

I.—PRACTICAL GEOMETRY: PLANE AND SOLID. 3/-

II.—MACHINE AND ENGINE DRAWING AND DESIGN. 4/6. Forming a complete Course. With numerous Examples and Illustrations prepared expressly for the work.

"A THOROUGHLY USEFUL WORK, exceedingly well written."—*Nature.*

Marine Engineering (A Manual of). The Designing, Construction, and Working of Marine Machinery. By A. E. SEATON, M.Inst.C.E., M.Inst.Mech.E., M.I.N.A. *Fourteenth Edition.* 21s.

Marine Engineering Rules and Tables. For Marine Engineers, Naval Architects, and others. By A. E. SEATON, M.Inst.C.E., and H. M. ROUNTHWAITE, M.Inst.Mech.E. With Illustrations. Leather. *Seventh Edition, Revised and Enlarged.* 8/6.

Munro's Steam Boilers. Their Defects, Management, and Construction. By E. D. MUNRO, Engineer of the Scottish Boiler Insurance and Engine Inspecting Company. *Third Edition.* Illustrated. 4/6.

Heat Efficiency of Steam Boilers: Land, Marine, and Locomotive. Showing results as to Evaporation, Heating Value of Fuel, Analyses of Gases, &c. By BRYAN DONKIN, M.Inst.C.E. With Diagrams and numerous Tables. 25/-

Gas, Oil, and Air Engines: Internal Combustion Motors without Boiler. By BRYAN DONKIN, M.Inst.C.E. *Third Edition, Revised and Enlarged.* Large 8vo, Handsome Cloth. Illustrated.

Pumping Machinery, its Principles and Construction (Steam and Water Pressure). By HENRY DAVEY, M.Inst.C.E., M.Inst.M.E., &c. With Plates and numerous Illustrations. 21/-

Hydraulic Power and Hydraulic Machinery. By HENRY ROBINSON, M.Inst.C.E., Professor of Civil Engineering, Kings' College, London. *Second Edition, Revised and Enlarged.* With 60 Plates. 84/-

Fuel and Water: A Manual for Users of Steam and Water. By Prof. FRANZ SCHWACHHÖFFER of Vienna, and WALTER E. BROWNE, M.A., C.E., late Fellow of Trinity College, Cambridge. Demy 8vo, with numerous Illustrations. 9/-

By W. J. MACQUORN RANKINE, LL.D., F.R.S.

I. **Applied Mechanics.** *Sixteenth Edition.* 12/6.

II. **Civil Engineering.** *Twenty-first Edition.* 16/-

III. **The Steam Engine and other Prime Movers.** *Fifteenth Edition.* 12/6.

IV. **Machinery and Millwork.** *Seventh Edition.* 12/6.

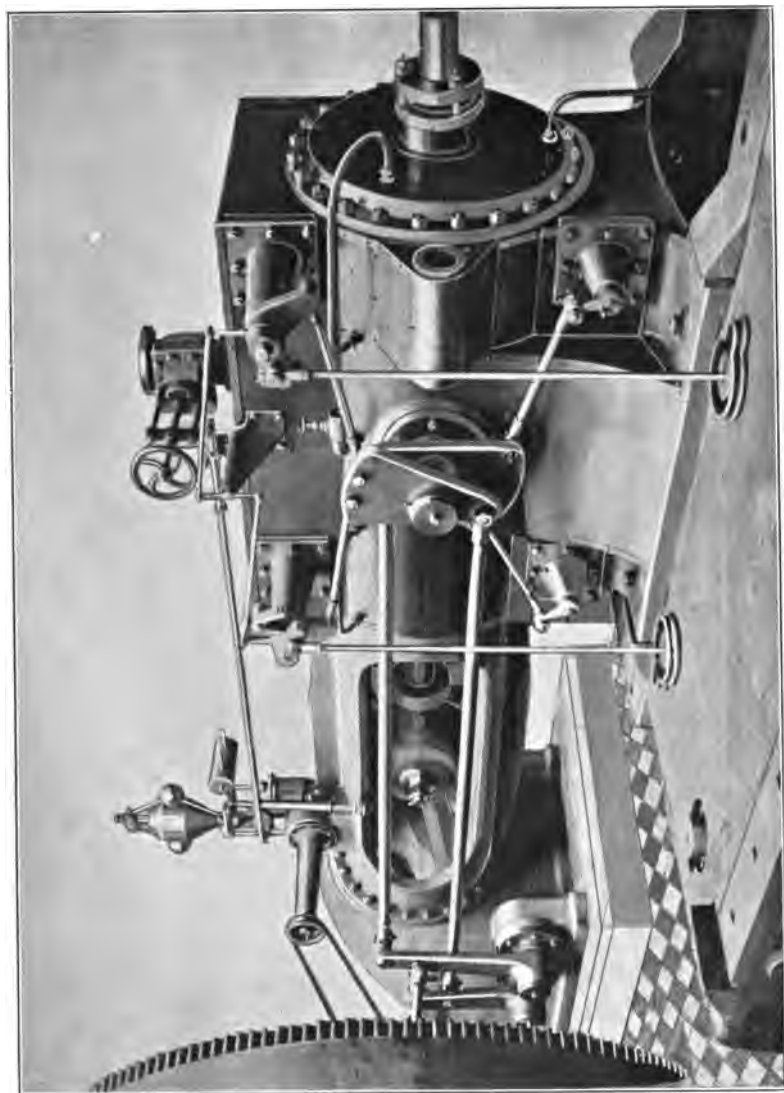
V. **Useful Rules and Tables:** for Engineers, Architects, Builders, Electricians, &c. *Seventh Edition.* 10/6.

VI. **A Mechanical Text-Book:** a Simple Introduction to the Study of Mechanics. *Fifth Edition.* 9/-

VIII. **Professor Rankine's Miscellaneous Scientific Papers.** With Memoir by Professor TAIT, M.A., and Fine Portrait on Steel. Royal 8vo, Handsome Cloth. 31/6.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.





COMPOUND CORLISS PUMPING ENGINE. VALVE GEAR OF HIGH-PRESSURE CYLINDER.
(Starting Platform Removed.)

Designed by the Author.

*Messrs. Manlove, Alliott & Co., Ltd.,
Engineers, Nottingham.*

VALVES

AND

VALVE-GEARING:

*A PRACTICAL TEXT-BOOK
FOR THE USE OF ENGINEERS, DRUGGISTS,
AND STUDENTS.*

BY
CHARLES HURST,
LONDON, AND MANCHESTER, ENGLAND.

THIRD EDITION, REVISED AND ENLARGED

With Frontispiece, Numerous Illustrations, and 5 Folding Plates



LONDON,
JOHN GRIFFIN AND COMPANY, LIMITED,
BAKER STREET, STRAND.

1902.

All Rights Reserved.



THE HOUSE OF REPRESENTATIVES

(The building shown in this photograph is the new one.)

Designed by the Architect.

VALVES

AND

VALVE - GEARING:

124461

*A PRACTICAL TEXT-BOOK
FOR THE USE OF ENGINEERS, DRAUGHTSMEN,
AND STUDENTS.*

BY

CHARLES HURST,
AUTHOR OF "HINTS ON STEAM ENGINE DESIGN," ETC.

THIRD EDITION, REVISED AND ENLARGED.

With Frontispiece, Numerous Illustrations, and 5 Folding Plates.



LONDON:
CHARLES GRIFFIN AND COMPANY, LIMITED;
EXETER STREET, STRAND.
1902.

[All Rights Reserved.]



Ms. B. 06-0002.

Rec'd 11-14-39 7M82

PREFACE TO THE THIRD EDITION.

IN this edition a Chapter on Drop Valve Gears has been added, and the original portion of the work has been revised.

BURTON JOYCE,
NOTTS, *November, 1902.*

PREFACE.

In the preparation of this work it has been my aim, as far as possible, to deal with the subject of Valve Gearing in a simple and interesting manner.

Whilst in the main adopting the Zeuner diagram, as being the most suitable for determining the proportions of Valve Gear, I have not confined myself exclusively to that method of solution; my object being to show that valve movements may be described in various ways, each possessing its own advantages.

In the First Part, chapter I. treats of the common Slide Valve and its modifications; the second chapter is devoted to Expansion Valves and Automatic Cut-off Gearing; and the remaining chapters deal with Link Motions and other Reversing Gears.

The Second Part treats of Corliss Valves and Trip Gears, a branch of the subject which has hitherto received but little attention from writers on Valve Gearing.

I have to acknowledge my indebtedness to several eminent firms who kindly furnished examples of the best modern gears; and I have also to thank my friend, Mr. F. H. Parker, for his assistance during the preparation of the work for press.

CHARLES HURST.

WIGAN, *June, 1897.*

CONTENTS.

PART I.—SLIDE VALVES.

Chapter I.—Simple Valve Gear.

| | PAGE | | PAGE |
|--|------|---|------|
| Area of Ports, | 1 | Ellipse Diagram, | 13 |
| Lead, | 2 | Double-ported Valves, | 15 |
| Point of Cut-off, | 2 | Trick Valve, | 16 |
| Diagram of Simple Valve, | 2 | Thom's Trick Valve, | 17 |
| Percentages of Release and Compression, | 7 | Valve Diagram for Tandem Engines, | 19 |
| Application of the Diagram, | 9 | Valve Spindles, | 20 |
| Divided Valves, | 9 | Valve Pins, | 23 |
| Valve Diagram, | 10 | Balanced Valves, | 23 |
| Effect of Connecting-rod and Equalisation of Steam Distribution, | 11 | Piston Valve, | 24 |

Chapter II.—Slide Expansion Gears.

| | | | |
|--|----|---|----|
| Expansion Gears, | 28 | Reynold's Valve Diagram for Meyer Gear, | 42 |
| Diagram for Expansion Gears, | 28 | Classes of Automatic Expansion Gear, | 43 |
| Application of Ellipse Diagram to Expansion Gears, | 32 | Hartnell's Governor, | 44 |
| Valve Diagram, | 33 | Diagram for Hartnell's Expansion Gear, | 44 |
| Design of Expansion Valves, | 34 | Application of the Diagram, | 45 |
| Meyer Expansion Gear, | 35 | Ruston Proctor's Expansion Gear, | 48 |
| Application of the Diagram, | 37 | Crank-shaft Governor Expansion Gear, | 48 |
| Expansion Regulator, | 37 | Westinghouse Governor, | 50 |
| Double-ported Meyer Gear, | 38 | | |
| Reynolds' Valve Diagram, | 41 | | |
| Reynolds' Valve Diagram for Single Valve, | 41 | | |

Chapter III.—Link Motions.

| | | | |
|---|----|---|----|
| Single Eccentric Reversing Gear, Valve Diagram for Shifting Eccentric Gear, | 52 | The Double Bar Link, with Eccentric-Rods inside, | 65 |
| Stephenson's Link Motion, | 54 | The Double Bar Link, with Eccentric-Rods outside, | 66 |
| Open and Crossed Rods, | 57 | Proportions of Links, | 67 |
| Valve Diagram for Stephenson's Link Motion, | 57 | Gooch's Link Motion, | 67 |
| Macfarlane Gray's Method of describing the Characteristic Line, | 59 | Eccentrics driving obliquely, | 69 |
| Crank Pin Diagram, | 63 | Valve Diagram for Gooch's Link Motion, | 71 |
| Best Arrangement of Gear, | 64 | Crank Pin Diagram, | 71 |
| Link Motion made by the North-Eastern Railway Co., | 65 | Best Arrangement of Gear, | 72 |
| The Slot Link, | 65 | Allan's Straight Link Motion, | 72 |
| | | Diagram for Allan's Gear, | 74 |
| | | Expansion Gear and Link Motions combined, | 75 |

Chapter IV.—Other Reversing Gears.

| | PAGE | | PAGE |
|----------------------------------|------|-------------------------------|------|
| Principle of Radial Gears, . . . | 76 | Hackworth's Valve Gear, . . . | 81 |
| Joy's Valve Gear, . . . | 76 | Bremme's Valve Gear, . . . | 82 |
| Diagram for setting out Joy's | | Comparison of Joy's and | |
| Valve Gear, . . . | 78 | Bremme's Gear, . . . | 84 |
| Joy's Gear on Marine Engine, . . | 81 | | |

PART II.—CORLISS VALVES.**Chapter I.—Gears without Trip Motion.**

| | | | |
|------------------------------------|----|-----------------------------------|-----|
| Advantages of Corliss Gears, . . | 87 | Position of Levers, . . . | 93 |
| Classification of Corliss Gears, . | 87 | Valve Diagram for Corliss Gear, . | 95 |
| Valve Gear without Trip Motion, . | 88 | Proportions of Steam Valve, . . | 97 |
| Effect of Wrist Plate, . . . | 89 | Proportions of Exhaust Valve, . | 98 |
| Reduction of Dwelling Angle, . . | 90 | Double-ported Valves, . . . | 98 |
| Location of Wrist-Plate Pin, . . | 91 | Equilibrium Corliss Valve, . . | 100 |
| Rules for Diameter of Valves, . . | 91 | Crank-Shaft Governors applied | |
| Angle of Vibration, . . . | 92 | to Corliss Valves, . . . | 101 |
| | | Diagrams of Valve Motion, . . | 101 |

Chapter II.—Single Eccentric Gears with Trip Motions.

| | | | |
|------------------------------------|-----|--------------------------------|-----|
| Principle of Trip Gears, . . . | 104 | Clearance of Catches, . . . | 109 |
| Advantages of Trip Gears, . . . | 104 | Movement of Trip Levers, . . | 109 |
| The Reynolds' Trip Gear, . . . | 104 | Cause of Popularity of Corliss | |
| Diagram showing Range of Trip, . | 106 | Gear in America, . . . | 111 |
| Diagram for Reynolds' Trip Gear, . | 108 | Arrangement of Link Work, . . | 111 |

Chapter III.—Double Eccentric Gears with Trip Motions.

| | | | |
|----------------------------------|-----|------------------------------------|-----|
| Movement of Valves in Double- | | Arrangement of Inglis and | |
| Eccentric Gears, . . . | 113 | Spencer Trip Gear, . . . | 119 |
| Diagram of Motion, . . . | 113 | Crab-Claw Trip Motion, . . . | 119 |
| Speed of Trip Gears, . . . | 114 | Ruston Proctor's Crab-Claw Gear, . | 120 |
| Range of Trip, . . . | 115 | Dobson's Trip Gear, . . . | 120 |
| Proportions of Valves, . . . | 115 | Valve Diagram for same, . . . | 121 |
| Musgrave's Trip Gear, . . . | 115 | Goodfellow's Gear, . . . | 123 |
| Inglis and Spencer Slip Rod, . . | 118 | Dashpots, . . . | 124 |

Chapter IV.—Single Eccentric Gears with Large Range of Trip.

| | | | |
|------------------------------------|-----|-----------------------------|-----|
| Frickart Single Eccentric Gear, . | 126 | Features of Cylinder, . . . | 131 |
| Valve Diagram for Frickart Gear, . | 128 | Wheelock Gear, . . . | 131 |
| Faroot Gear, . . . | 129 | | |

**PART IIL—DOUBLE-BEAT VALVES AND
MISCELLANEOUS GEARS.**

| | PAGE | | PAGE |
|------------------------------|------|-------------------------------|------|
| Cornish Valves, | 135 | Diagram for do., | 140 |
| Lift of do., | 135 | Sulzer Gear, | 145 |
| Width of Seat, | 136 | Beadle's Rotary Valve Gear, . | 146 |
| Four-faced Valve, | 137 | Duplex Pump Valve Gear, . | 148 |
| Cornish Valve Motion, . . . | 137 | Diagram of Levers for do., . | 150 |
| Winding Engine Valve Gear, . | 139 | | |
| INDEX, | | | 151 |

VALVES AND VALVE - GEARING.

PART I.

SLIDE VALVES.

CHAPTER I.

SIMPLE VALVE GEAR.

CONTENTS.—Area of Ports—Lead—Point of Cut-off—Diagram of Simple Valve—Percentages of Release and Compression—Application of the Diagram—Divided Valves—Valve Diagram—Effect of Connecting-rod Angularity and Equalisation of Steam Distribution—Ellipse Diagram—Double-Ported Valve—Trick Valve—Thom's Trick Valve—Valve Diagram for Tandem Engines—Valve Spindles—Valve Pins—Balanced Valves—Piston Valve.

In dealing with valve gears, the common slide valve suggests itself as being a suitable starting point, for once the simple diagrams and requirements relating to it are understood, the subject leads easily and naturally to the consideration of more complex gears.

Area of Ports.—The first consideration when designing any valve gear is the amount of steam and exhaust openings requisite for the free passage of steam. It has been found that the velocity of steam entering the cylinder should not exceed 6,000 to 7,800 feet per minute; while that of the exhaust should not exceed 4,800 to 6,800 feet per minute.

Let A = area of port opening in square inches.

D = diameter of cylinder in inches.

P = piston speed in feet per minute.

V = mean velocity of steam in feet per minute.

V^1 = mean velocity of exhaust in feet per minute.

Then

$$A = \frac{D^2 \frac{\pi}{4} \times P}{V}.$$

The area of opening for exhaust will be—

$$\frac{D^2 \frac{\pi}{4} \times P}{V^1}.$$

In deciding upon the values of V and V^1 , regard must be had to the length and shape of the ports, and to the intended pressure of steam. In long-stroke slide valve engines the lesser velocities should be taken; but in Corliss engines, where the ports are short and direct, the higher values of V and V^1 may be taken without fear of wiredrawing. The frictional loss of steam in the ports is proportional to its density; hence it is necessary to consider the pressure when calculating the area of passages. An instance of the effect of this consideration may be found in a well-designed compound engine. In the high-pressure cylinder the ports may have such an area as will give a velocity of, say, 5,700 feet per minute to the steam and 5,200 to exhaust; but in the low-pressure cylinder it is not uncommon to find these velocities to be 7,200 and 6,500 respectively.

Having determined the area of the ports, the length must be fixed upon to find the width; or, if the width be settled, the length is easily found. It is to be noted that the steam port should be equal in area to the amount given by the formula for exhaust—that is, in slide valve engines—as it is evident that the exhaust must pass through the steam port. Allowance should be made for any ribs which may be cast in the ports, as they contract the passages.

Lead.—In fixing the amount of lead, the chief point requiring attention is the piston speed. Other things being equal, the lead increases as the piston speed. Large clearance engines require more lead than Corliss engines. A common practice is to allow in medium-stroke engines $\frac{1}{8}$ inch linear lead for every 100 feet of piston velocity. In vertical engines the lead on the top side of the cylinder is less than on the bottom, for two reasons. Firstly, because gravity is against the piston, piston-rod, crosshead, and connecting-rod on the up-stroke; and secondly, because most of the wear in the joints of the link is in a downward direction. It is a common practice, when first setting vertical engines to work, to give on the top side half the lead given on the bottom end.

Point of Cut-off.—The percentage of cut-off with a common slide valve may be from $\frac{1}{8}$ to $\frac{1}{4}$ of the stroke. Greater expansion than the earlier cut-off given should be obtained by expansion valves; with a later cut-off than $\frac{1}{4}$ there is likely to be excessive back pressure. A cut-off at 75 per cent. is very convenient; the exhaust and compression then being quite satisfactory, and the travel of the valve not abnormal.

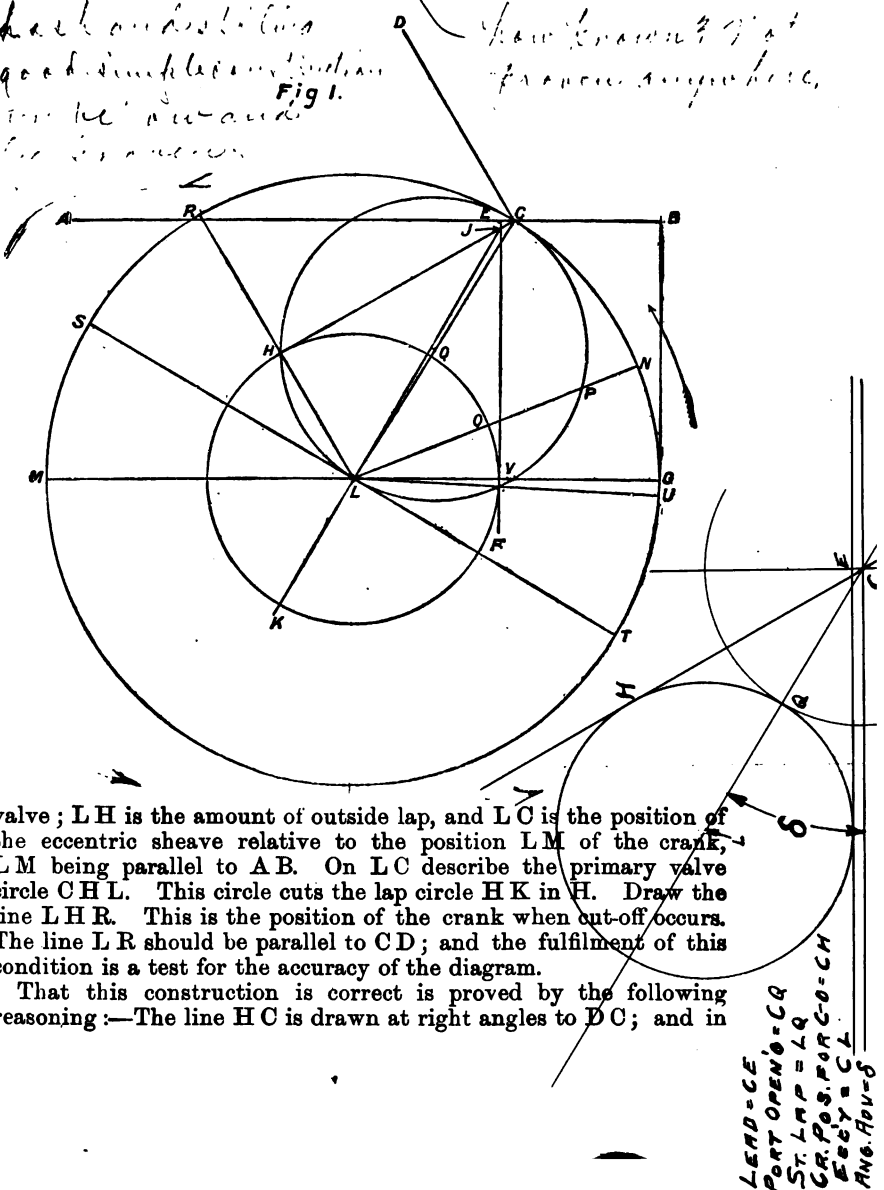
Having decided upon these points—namely, the port opening, the lead, and the percentage of cut-off—the design of the valve may be at once proceeded with.

Diagram of Simple Valve.—On a horizontal line A B (Fig. 1),

draw CD for the position of the crank when steam shall be cut-off. From C, make OE equal to the lead, and draw EF perpendicular to AB. Draw BG parallel to EF, making EB equal to the required width of steam opening. Next, draw OH at right angles to CD, cutting the line EF at J. Bisect HJF by line JK. On JK find the centre of a circle which shall pass through O and touch the line BG. Let L be the centre thus found. Then, in the diagram, LC or LG equals the throw of the eccentric, or half the travel of the

*Another method of finding
of a good simple construction
is shown here and
is simpler than the
Fig 1.*

*How known? Not
from anywhere.*



valve ; LH is the amount of outside lap, and LC is the position of the eccentric sheave relative to the position LM of the crank, LM being parallel to AB. On LC describe the primary valve circle CHL. This circle cuts the lap circle HK in H. Draw the line LHR. This is the position of the crank when cut-off occurs. The line LR should be parallel to CD ; and the fulfilment of this condition is a test for the accuracy of the diagram.

That this construction is correct is proved by the following reasoning :—The line HC is drawn at right angles to DC ; and in

LEAD = CE
PORT OPENING = CQ
ST. LAP = LQ
CR. POS. FOR C-O = CH
ECCY = CL
ANG. ADV = δ

the semicircle LHC , the angle CHL is a right angle (Euclid's Elements, Bk. iii., Prop. 31); LR is therefore at right angles to HC , and, consequently, parallel to DC .

Again, because the circle HKO is drawn so that the line HO is tangent, the line LR is at right angles to that tangent (Euclid, Bk. iii., Prop. 18), and therefore parallel to the given line of cut-off DC .

That the maximum port opening is equal to the given amount EB can readily be shown. The line EF is drawn at right angles to AB , and so is line BG . Therefore, EF and BG are parallel. The line EF is also tangent to the circle KHO , by construction; and, therefore, since the half travel of a slide valve is occupied by lap and port opening, the distance LG is equal to the port opening *plus* the lap. But it has been shown that VG is equal to the port opening; therefore LV is the lap

The whole principle of the Zeuner diagram is directly founded on the 31st proposition of Euclid's third book; and the truth of all diagrams can be proved by reasoning similar to that given above.

Taking any position of the crank, as at LN , the condition of things is clearly shown by the diagram. The port will be open to steam an amount equal to OP , given by the distance between the lap circle and the valve circle on the line of the then position of the crank. Also, at this position, the valve is distant to the left of its central position an amount equal to LP . At crank position LO the valve is at its greatest distance to the left of its central position, the port opening being equal to QC ; QO being equal to EB as arranged for. Again, at LR the valve has just closed the port; LH being its displacement to the left of its mid position. At LS the valve has arrived at its central position and travels to the right until LK is reached. It now returns and arrives at its central position at LT ; the line ST being at right angles to LC . At LU the port is open ready for the commencement of the stroke.

Thus far only the action of the entering steam has been considered. In order to study the exhaust Fig. 2 is constructed. In actual working this diagram would not be drawn separately, but it is to facilitate explanation and avoid confusion that two diagrams have been drawn in this instance.

Make LC , LH , and angle CLU , respectively, equal to LC , LH , and angle CLU in the first diagram. Produce CL to V , and on LV describe the secondary valve circle. Now, as the primary valve circle gave the port openings to steam for any crank position from T to S , so will the secondary valve circle give the port openings and valve positions for any point of the stroke from S to T , in the direction of the arrow.

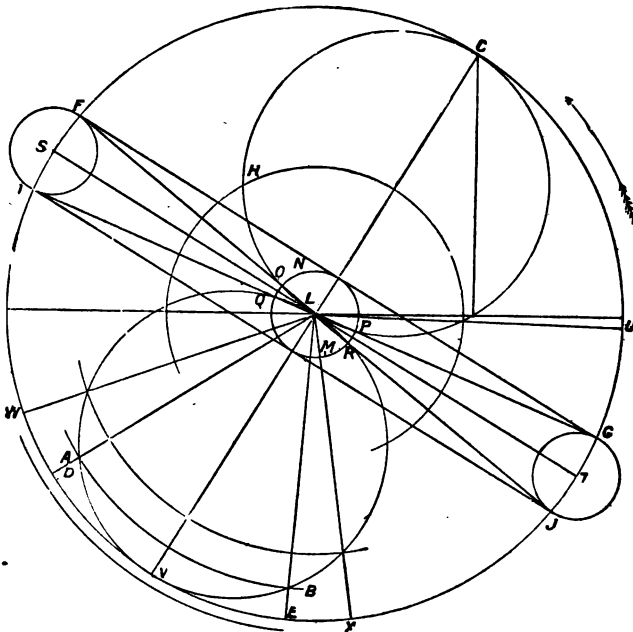
Taking a case in which there is no inside lap, at crank position LS , the valve is in its central position, as previously explained; and it is evident that when it is in this position the valve is about to open for exhaust either one port or the other. LS , therefore, represents the position of the crank when release occurs. The port is being opened from S to V . Of course, the opening cannot

Where
the
crank
is
positioned

exceed the width of the steam port, so that, if from L as centre, an arc A B be struck, the radius of which is equal to the width of the steam port, it is clear that the maximum port opening is attained at crank position L D, and this opening is maintained till L E is reached. At this point reduction commences and continues till L T. At L T the port is closed, and the steam remaining in the ports and cylinder is compressed until admission occurs at L U.

Considering now the effect of inside lap, it will be observed that positive inside lap delays release and hastens compression ; while negative lap has the reverse effect in an equal degree. From L as

Fig. 2.

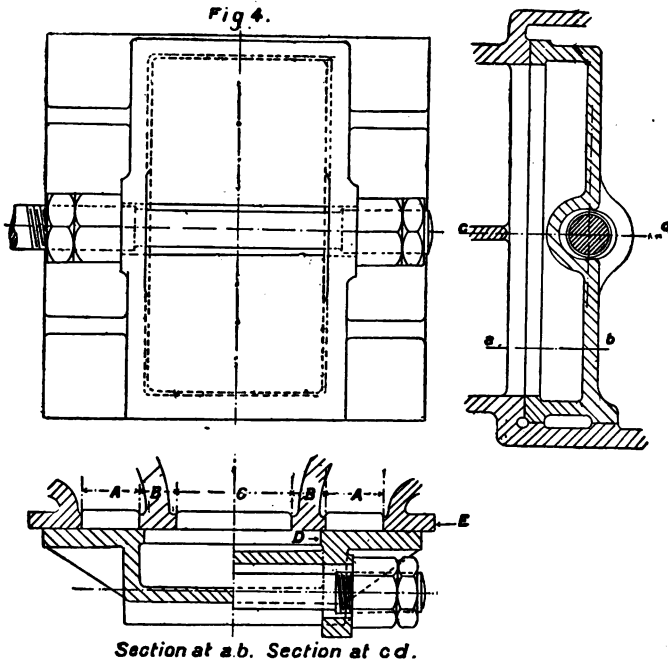


centre, and with radius equal to the inside lap, either negative or positive, describe the circle M N. This circle cuts the primary valve circle at the points O and P, and the secondary circle at Q and R. From L draw lines passing through these points, and produce them to the circle C D E. Then, with positive lap, L I is the position of the crank at release, and L J its position at compression. With negative lap, L F is the release position, and L G compression position. The same result may be obtained by a different method. On S and T as centres, and with radius equal to M N (the inside lap), describe the circles I F and G J. These circles cut the valve travel circle at points F G I and J, and these are the required points.

H and J respectively ; and these points will be the nearest approach to the required distribution that it is possible to attain. When the line joining the two given crank positions intersects the primary valve circle the lap will be negative ; and when that line intersects the secondary valve circle the lap will be positive ; and when the line is at right angles to the centre line of the valve circles there will be no inside lap whatever.

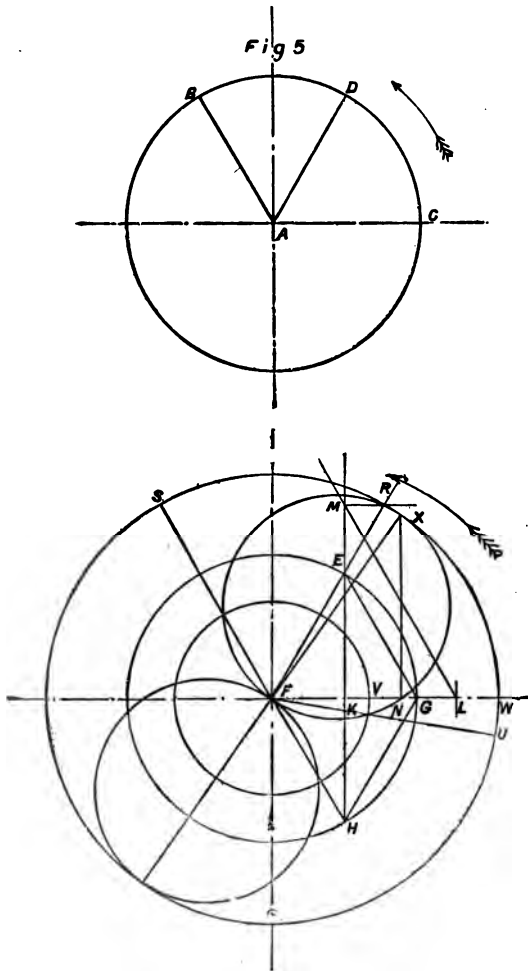
In Fig. 2, if there be negative lap equal to $L N$, the port will be fully open to exhaust at crank position $L W$; the arc, whose radius equals the width of the steam port minus negative lap, being struck from L as centre. $L X$ is the point at which reduction commences. With the same amount of positive lap, it is evident that the port will never be fully open to exhaust, as shown by the arc falling without the valve travel circle.

Percentages of Release and Compression.—In determining the most suitable point for compression, the clearance is the chief



point to consider. The most satisfactory way is to plot down the probable indicator diagram, and by means of the hyperbolic curve, to find a compression that will give a final pressure in the cylinder to balance the momentum of the moving parts. Having settled on this point, the valve diagram is drawn, and the release point finds itself. It is possible that release may fall before cut-off, in which

case less compression must suffice in order to cause release to fall later in the stroke. Release at 92 per cent., and compression at 89 per cent., have been found very satisfactory for horizontal engines, with piston speeds of from 450 to 600 feet per minute,



and with clearance volumes of from 5 to 10 per cent. of the piston's displacement.

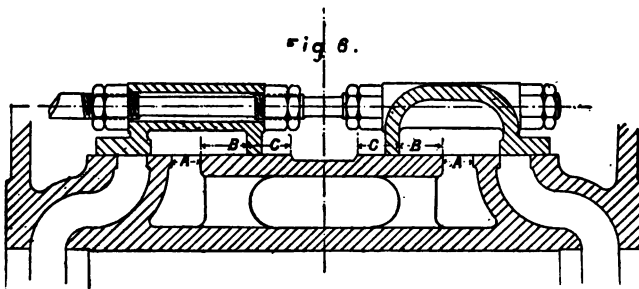
In high-speed vertical engines, it is the practice to give more compression on the under side of the piston, in order to counteract gravity. A compression at 82 per cent. on the bottom side is not uncommon in such cases.

Application of the Diagram.—The practical application of the valve diagram is illustrated by Fig. 4. A is the width of the steam port as obtained by calculation. B may be any convenient dimension. Then C should equal distance LC (i.e., half travel of valve, see Figs. 1 and 2) $+ A$ (Fig. 4) $+ L$; L being *plus* for positive inside lap, and *minus* for negative inside lap. When the port and valve faces are thus designed, the port opening through C will never be less than the width of the steam port; that is, assuming that the width of the bar, B , is less than $LC - L$ when there is positive lap; and $LC + L$ when there is negative lap. The edge of the valve, D , must on no account slide past the outer edge of the port face, E .

The following is a very useful extension of the Zeuner diagram for solving the foregoing problem:—

Let AB in the upper diagram of Fig. 5 represent the position of the crank when it is desired to cut off. Bisect the angle BAC by the line AD . In the lower diagram, draw the circle EH equal to the assumed circle BDC above. Make angles GFE and GFH both equal to angle DAB or DAC ; and join E and H by the line crossing the horizontal at K . From K , lay off KL equal to the required maximum port opening *minus* half the lead the valve is to have. Join GE , and draw LM parallel to GE , cutting HE produced, in M . From M draw the horizontal MR , intersecting FE produced, in R . Then FR is the half travel of the valve. Draw the circle RSW . From W , lay off the maximum port opening WV , which discovers the lap FV . Draw the lap circle; and make VN equal the given lead. Draw the perpendicular NX . Then FX is the eccentric position when the crank is on dead centre; and drawing the valve circle having FX as a diameter, will show the steam action. In the figure, admission is seen to be at FV , and cut-off at FS , and FS is parallel to AB above.

Divided Valves.—When the stroke of an engine is very long in proportion to the diameter of the cylinder, the clearance with a



slide valve is great. This clearance, however, may be considerably reduced by placing a valve at each end of the cylinder. Fig. 6 shows such an arrangement. The section of the front valve is taken

through the boss for spindle; whilst the back is shown by a section above the spindle, and shows the dish-shaped form of the valve.

The proportions of the port and valve faces are here given.

A = width of steam port.

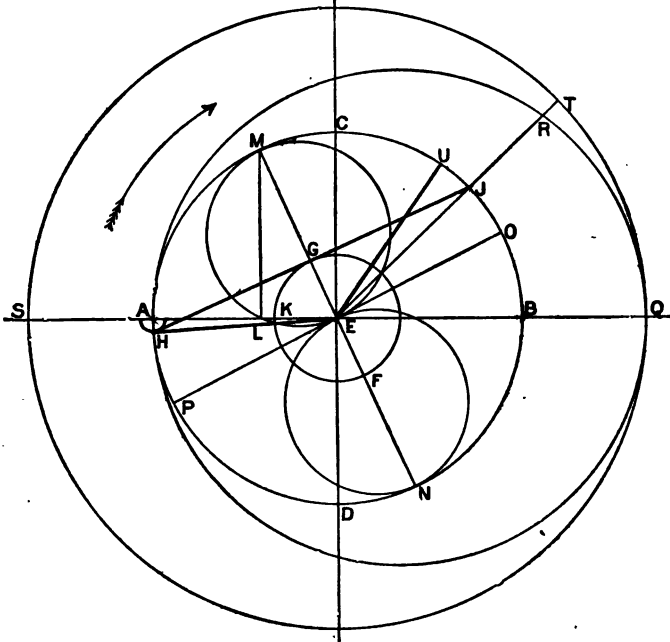
B = half travel of valve.

C = half travel of valve + $\frac{1}{2}$ inch to 1 inch.

A case may frequently arise in which the travel of the valve, lap, and lead are known, and it is required to find the points of cut-off, release, and compression. This problem presents itself when the actions of existing valves are being considered, so that alterations can be made if the steam distribution be found unsatisfactory.

Valve Diagram.—On A B (Fig. 7) draw the circle A B C D, equal in diameter to the given travel of the valve. From centre

Fig 7.



E, and with radius equal to the given outside lap, describe the circle F G. From centre A, and with radius equal to the given lead, describe the circle. The line H J drawn as a tangent to the lap and lead circles cuts the circle A B C D in H and J. E H is the position of the crank when admission takes place, and E J is the crank position at cut-off. From K, set off K L equal to the lead,

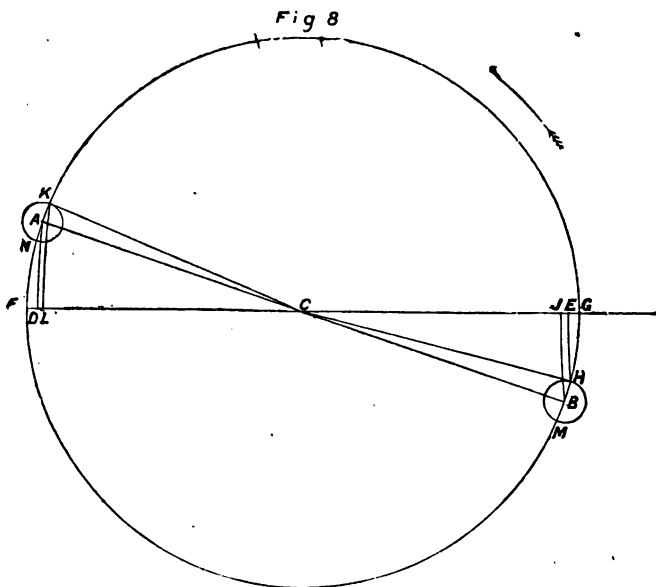
and erect a perpendicular L M. Join E and M. Then E M is the position of the eccentric sheave relative to the position of the crank E B. Produce M E to N, and on line M N describe the primary and secondary valve circles. The completion of the diagram is now a simple matter, and it will suffice to say that E O is release point, and E P compression point, the valve having no inside lap. The arrow indicates the direction of rotation, or rather the direction in which the steam distribution is traced; and although the eccentric is spoken of as being at E M, it should be remembered that this is its position relative to the real position of the crank E B, as said. To show the eccentric relative to the crank when at A E, the line E U is drawn; angle O E U being equal to angle C E M.

In all cases connected with the ordinary slide valve, it is well to remember that the crank being on dead centre, the centre of the eccentric sheave is in advance of the crank by 90 degrees *plus* the angle necessary for lap and lead; and further, if the valve had neither lap nor lead, the eccentric sheave would be at right angles to the crank and leading.

If, to any convenient scale, B Q be made equal to the stroke of the piston, the distance of the piston from the beginning of the stroke for any crank position is given by the distance between the valve travel circle A B C, and the circle Q R A, on the line indicating that position. Thus, at crank position E J, J R is the distance of the piston from the beginning of the stroke. Similarly, the circle Q T S gives the distance of the piston from the end of the stroke for any crank position. At crank position E J, R T is the distance of the piston from the end of the stroke. $J R + R T = B Q$, wherever J R and R T may be.

Effect of Connecting-Rod and Equalisation of Steam Distribution.—In all previous diagrams the angularity of the connecting-rod has been neglected; but in most cases it is necessary to take this angularity into account. The Zeuner diagram admits of this, but not of that of the eccentric-rod; the ratio of the length of the eccentric-rod to its travel, however, being in most cases great may be neglected. The effect of connecting-rod angularity is to cause events in the forward stroke to occur later than the corresponding events in the back stroke. Thus, a connecting-rod of five cranks in length would cause a cut-off at 75 per cent. in the forward stroke to occur at 68.75 per cent. in the back stroke; and with a shorter rod the difference would be greater. It is possible to equalise these events. It is also possible to equalise release and compression; and Fig. 8 shows how this may be done. Let O A be the crank position at release for the forward stroke. It is required to cause release in the back stroke to occur at the same fraction as in the front stroke. Produce the line F G, and with a centre somewhere on this line describe the arc A D, the radius of which bears the same ratio to distance A C, as the connecting-rod bears to the crank. F G representing the stroke of the engine, it is evident that the piston has travelled a distance G D from the

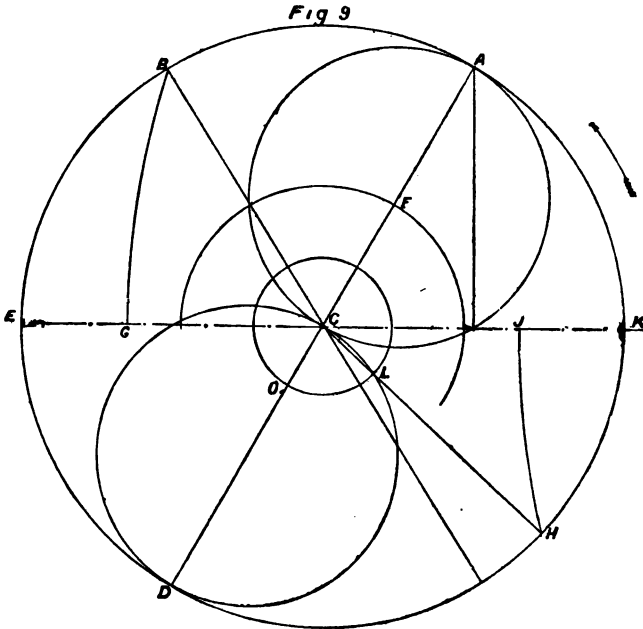
beginning of the stroke when release occurs; and AC is the corresponding crank position for this point. From G , make GE equal to FD . With centre on FG produced draw the arc EH . Produce CA to B . The distance BH will represent the difference between the inside lap of the front end of the valve and the inside lap of the back end. For example, suppose that in order to release at AC in the front stroke no inside lap were required; then the back end of the valve would have no lap, for it is the back end of the valve which controls the forward stroke. But if release is to occur at CH in the backward stroke, the front end of the valve must have positive inside lap equal to BH , because the front end controls the backward stroke.



Dealing now with compression, it will be observed that if CB represent the crank position when this event takes place, the piston will be distance GJ from the end of the backward stroke; FG representing, as before, the whole stroke. From F , make FL equal to GJ , and draw the arc LK . Produce CB to A . Then AK will be the difference between the inside laps of the valve in order to equalise compression. In the present instance $BH = AK$; therefore both compression and release are equalised.

It has been mentioned that cut-off may be equalised. Fig. 9 shows how this may be effected:— CB is the position of the crank at cut-off, in the forward stroke. AC is the centre line of the eccentric. Produce AC to D ; and on AD describe the valve circles. CF is the lap circle for the back end of the valve. With

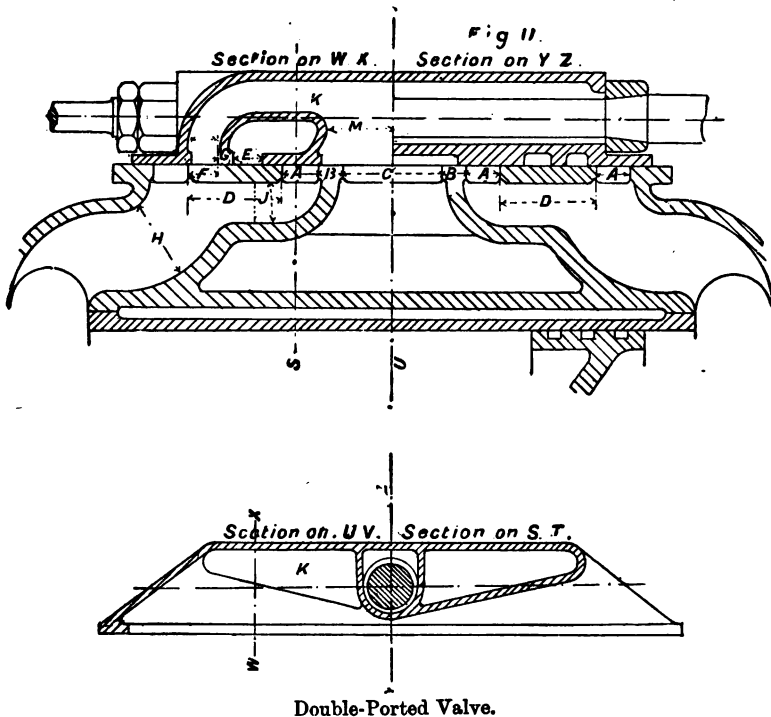
the length of the connecting-rod as radius, draw the arc BG. Make JK equal to EG, and draw the arc HJ. Join C and H. Where CH crosses the secondary valve circle (this circle being really the primary circle for the back stroke) describe the circle LO, the radius of which will be the necessary outside lap for the front end of the valve. Equalisation of cut-off has been obtained at the expense of unequal port openings (FA being the amount for the back port, and OD the amount for front port) and unequal leads. This is a serious objection; hence, equalisation of cut-off with the common slide valve is never attempted in practice.



Ellipse Diagram.—A convenient way of studying the action of the slide valve is to plot the motion of the piston as abscissa, and that of the valve as ordinate. On a horizontal line (Fig. 10) draw the path of the crank pin to any convenient scale, and divide it into any number of equal parts. On the horizontal line, and to any convenient scale, draw the eccentric circle. Make the angle Gca' equal to the angular advance of the eccentric. From a' divide the circle into equal parts to correspond with the crank-pin circle. Draw the arcs for the connecting-rod and the eccentric-rod, the centre line of the eccentric-rod, AB, being at right angles to the centre line of the crank-pin circle, AG. Starting at point a on the crank-pin circle, erect a perpendicular al . a' is the corresponding eccentric position, and D will be the valve position. Project D l

centages may be easily obtained. When the piston is at *a*—that is, the beginning of the stroke—the valve will be distant, *a E*, from its mid position. Again, at piston position, *H*—the projection of *F*—*H F* is the displacement of the valve from its central position, and the port is just closed to steam. If *J K* be parallel to *a G*, and remote a distance equal to the positive inside lap, *K* and *J* will be the points of release and compression respectively. For negative inside lap, *L M* would be drawn above *a G*; and *L* and *M* would be the points of compression and release respectively. The upper shaded portion of the figure will give the port openings to steam for any crank position; whilst the lower shaded portion illustrates the opening to exhaust.

It is evident that this diagram is not suitable when designing new valves, but for tracing the action of existing gear, where the travel of the valve and the angle of advance are known, it is very convenient, inasmuch as it permits of both connecting-rod and eccentric-rod being taken into account. This is the only advantage over Zeuner's diagram.



Double-Ported Valves.—Cylinders of large size require ports of considerable width; and consequently, the necessary travel of

the valve becomes excessive. Other things being equal, the work required to actuate the valve varies directly as the travel; hence it is desirable to make the travel as small as possible. The double-ported valve gives twice the steam opening of an ordinary valve with the same travel, and is much used for large cylinders. The valve diagram is drawn exactly as for an ordinary valve. The port openings and lead, however, will be twice the amount shown by the diagram. An example of a double-ported valve is given in Fig. 11. The correct proportions of the port and valve faces are here given :—

- A = half total width of required exhaust opening.
- C = $2A + \text{half travel of valve} \pm \text{inside lap} (+L \text{ for positive lap, } - \text{ for neg.}) - B$.
- E = half total width of required steam opening.
- F = half travel of valve.
- D = $E + G + F + \text{outside lap}$.
- J = A.
- H = $2A$.

Area of passage K = area of one steam port.

M = not less than A; preferably more.

B and G, of course, are empirical.

The figure shows a valve suitable for a vertical engine. The spindle is prolonged to carry a balance piston at the top of the steam chest. The chipping strips at the entrance of the valve ports not only facilitate the finishing up to the exact sizes, but give an increased area for steam through the valve. This is an advantage; for it is evident that the boss round the valve spindle reduces the area of these passages. The chipping pieces compensate for this reduction.

Trick Valve.—Fig. 12 shows a form of slide known as the trick valve; a design which gives a better steam opening than an ordinary valve. An inspection of the figure will render its action apparent. E is a passage in the valve which will admit steam from the left-hand side of the valve to the right-hand port, or from the right-hand side of the valve to the left-hand port, when the edge of the valve T slides past the end of the port face. The port and valve faces are so disposed that at the instant this occurs, the port will also be opened by the edge F, thus admitting steam as an ordinary slide valve. The proportions of this valve are as follows :—

B = half required width of port opening.

A = $2B + C$, if sufficient for exhaust.

L is the outside lap, as obtained from valve diagram.

D = L.

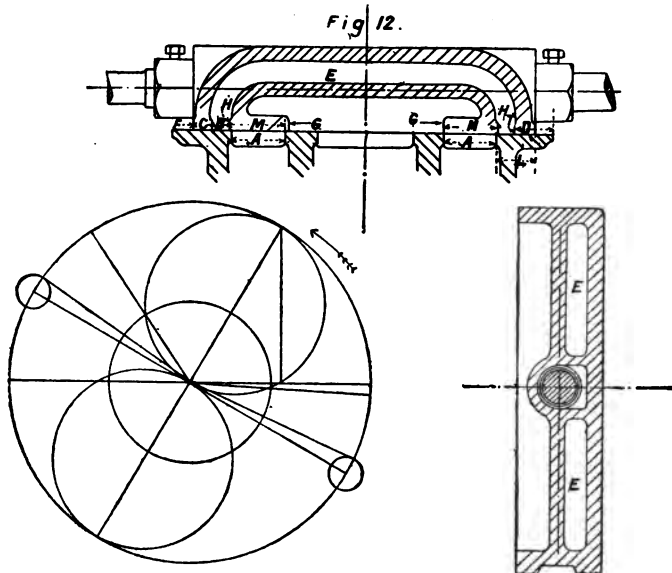
M = half travel of valve.

Area of passage E = half area of port opening.

It is important that the edges H do not open the port before the edges G have closed; otherwise, the steam in passage E will be lost at each stroke. When the above proportions do not admit of this, B may be reduced the required amount, the reduction being

compensated by an increased opening past the edge F; which means a little extra travel. If the point of cut-off is to be maintained, the increased travel will alter the lap; and it is probable that the ports will have to be re-arranged to suit the altered circumstances.

The valve diagram calls for no comment, except that the true port opening is not the amount shown by the figure. The lead is twice the amount shown. An equalisation of release and compression.

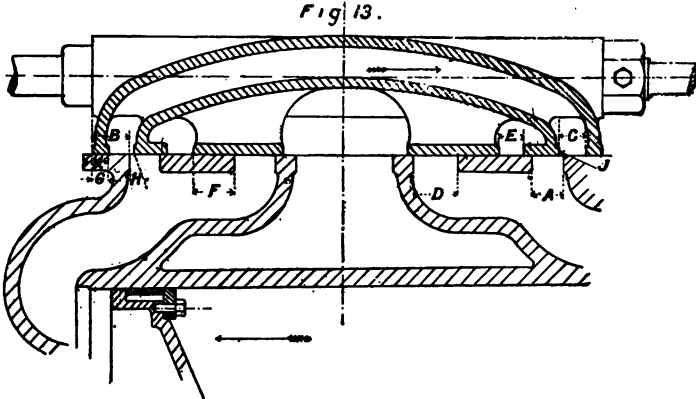


Trick Valve.

sion has been obtained by inside lap on the front end of the valve. The trick valve should have chipping strips at the edge of the ports in order to compensate for the reduction of area due to the boss of the valve spindle.

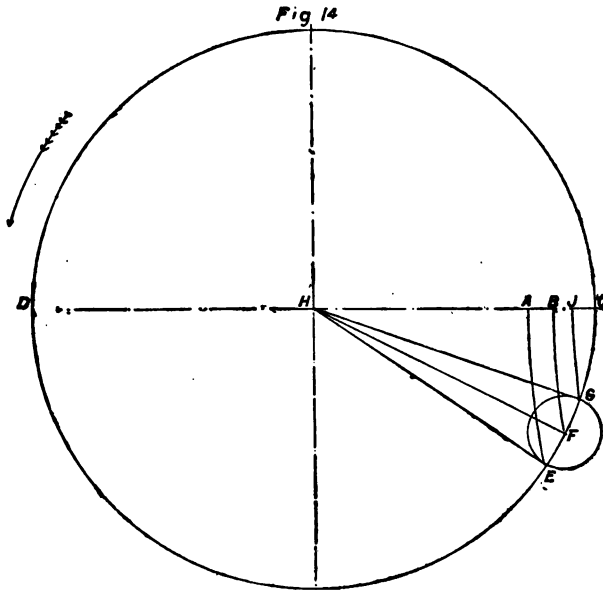
Thom's Trick Valve.—Thom's patent trick valve is an ingenious and useful invention, and has been successfully applied to many low-pressure cylinders of marine engines. In Fig. 13, the valve is shown in its central position, and the corresponding position of the piston is also indicated. Under these conditions, steam is entering from the top, through the patent passage, to the bottom side of the piston. A slight movement of the valve in the upward direction will destroy this connection; and the piston, continuing its down stroke, will compress the steam remaining in the cylinder and port at the bottom end. When it is remembered that the terminal pressure of most condensing engines is very low, the difficulty of obtaining satisfactory compression will be appreciated: and the

advantage of this valve is, that it substitutes steam of a pressure equal to that at release point, in place of a vacuum that approxi-



Thom's Trick Valve.

mates to that of the condenser. A proper compression is thus obtained, the ports are hotter at the commencement of the next



stroke than they would otherwise be, and hence there is less condensation ; and a saving of steam at release point pressure, and in

volume equal to the capacity of the ports and clearance, will be effected at each revolution.

The proportions of this valve may be as follows:—

B = lap as obtained from diagram.

C = half required width of port opening (steam).

A = $2C + G$.

K = B.

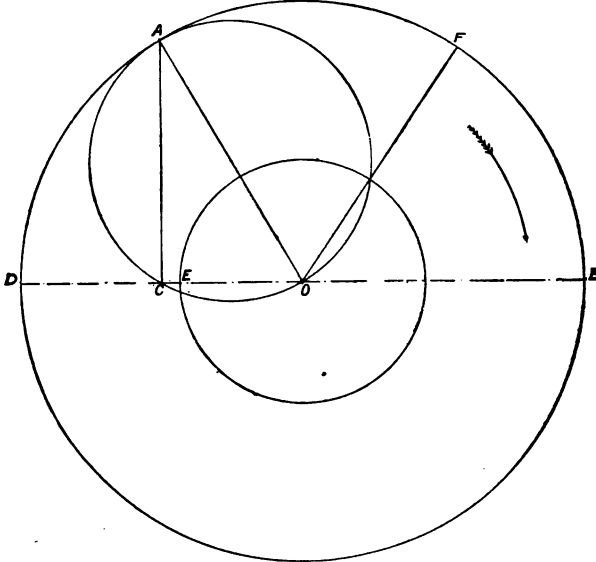
D + E = necessary width for exhaust.

F = half travel of valve + say $\frac{1}{2}$ inch for tightness.

It will suffice if the communication between the ends of the cylinder occur when the valve has moved in a position in which the exhaust has closed by about $\frac{3}{8}$ of an inch. The accompanying diagram will illustrate the action. Let OD represent the travel of the valve and also the stroke of the piston. Let HE be the position of the crank when compression commences, the direction of rotation being that indicated. The corresponding position of the piston is A. Make EF equal to the desired cover of the valve before communication takes place. HF is the crank position, and B the piston position when communication takes place. Let FG equal H (Fig. 13), the distance between the edge of the valve J and the edge of the port. Then communication will exist while the crank is travelling from F to G, and the piston from B to J.

Valve Diagram for Tandem Engines.—In tandem engines,

Fig 15.



where the valve of the back cylinder is worked by a prolongation of the valve spindle of the front cylinder, it is evident that the

travels and the advance angles of the two valves will be the same. Suppose the front valve already designed. Having decided upon the lead of the back valve, all necessary data are to hand for the construction of a diagram. From O as centre, draw the valve travel circle A B D. Draw O A, the given position of the eccentric in relation to the real position of the crank O B. Draw A C perpendicular to B D; and from c, mark off C E, equal to the lead. E O will be the lap. Draw the lap circle. Describe also the valve circle, giving by its intersection with the lap circle, the position of the crank at cut-off O F. E D is the maximum width of steam port opening; the area of which being known, the length is obtained. Should this be found inconveniently long, a trick valve, or a double ported valve, would perhaps set matters right in this respect; or the front valve ports might be altered so as to overcome the difficulty. O F also may be found unsuitable; in which case, a compromise between the two cylinders may be effected, in order that this objection may be removed, or at least mitigated.

Valve Spindles.—The determination of the size of valve spindles requires careful consideration, in order that they may perform their work without trembling or buckling.

Let μ = coefficient of friction between valve and port faces. (Take 0.2, which allows for weight of valve and friction of stuffing boxes.)

P = pressure of steam in valve chest, in lbs. per sq. inch.

S = working stress on valve spindle at smallest diameter. (5000 to 6000 lbs. per sq. inch for steel; 4000 to 5000 for iron.)

A = full area of back of valve in sq. inches.

Then area of spindle at smallest diameter = $\frac{\mu P A}{S}$; which rule

agrees closely with practice. But this rule must not be applied in every case; for other considerations may modify the dimension thus found. In cases where the distance from the valve to the spindle guide is considerable, and where the eccentrics are not in line with the valve spindle, which would cause a bending action on the latter, it would be advisable to exceed the dimension found by formula.

The following table, collated from actual and recent practice, will serve to show the effect of various conditions that influence the dimensions of valve spindles:—

| Description of Engine. | Boiler Pressure. | Extreme Dimensions of Valve in inches. | Distance from centre of Valve to Guide in ins. | Diameter of Valve Spindle at Stuffing Box in inches. | Remarks. |
|---|------------------|--|--|--|--|
| Vertical triple expansion condensing, 8-in. high-press. cylinder, . . . | 160 | $7\frac{1}{2} \times 7\frac{1}{2}$ | ... | $1\frac{1}{4}$ | Simple slide valve. Steel spindle. No guide for spindle other than stuffing box. From centre of valve to centre of eye in valve spindle $2' 4\frac{1}{4}"$. Maximum pressure in valve chest $7\frac{1}{2}$ lbs. |
| 13-in. intermediate cylinder for above engine, . . . | ... | $7\frac{1}{2} \times 10\frac{1}{2}$ | ... | $1\frac{1}{4}$ | Same remarks apply. Maximum pressure in valve chest $7\frac{1}{2}$ lbs. |
| 22-in. low-press. cylinder for above engine, . . . | ... | 8×18 | ... | $1\frac{1}{4}$ | Same remarks apply. Maximum pressure in valve chest 16 lbs. |
| 17 $\frac{1}{2}$ -in. locomotive, . . . | 140 | 11×14 | 48 | $1\frac{1}{4}$ | Simple slide valve. Yorkshire iron case-hardened spindle. |
| Horizontal twin compound condensing, 25-in. high-press. cylinder, . . . | 100 | 20×22 main valve, $7\frac{1}{2} \times 21$ cut-off valves, | 96 | $2\frac{1}{2}$ main, $2\frac{1}{2}$ cut-off, | Meyer expansion gear. Steel spindles |
| 44-in. low-press. cylinder for above engine, . . . | ... | 40×42 main valve, 10×42 cut-off valves, | 96 | $2\frac{1}{2}$ main, $2\frac{1}{2}$ cut-off, | Double-ported Meyer expansion gear. Steel spindles. Maximum pressure in valve chest 32 lbs. |
| 60-in. low-press. cylinder of compound vertical condensing engine, . . . | ... | 52×48 | 77 | $3\frac{1}{4}$ | Double-ported valve. Steel spindle. Maximum pressure in steam chest 25 lbs. |
| Horizontal tandem compound condensing, 13-in. high-press. cylinder, . . . | 140 | $11\frac{1}{2} \times 12$ main valve, 5×12 cut-off valves, | 66 | $2\frac{1}{2}$ main, $1\frac{1}{2}$ cut-off, | Meyer expansion gear. Short valve at each end of steam chest, fitted with relief ring. Main valve spindle prolonged to work low-press. valve. Steel spindles. |
| 27-in. low-press. cylinder for above engine, . . . | ... | $14 \times 22\frac{1}{2}$ | 60 | $1\frac{1}{2}$ | Simple slide valve. Steel spindle. Maximum pressure in valve chest 38 lbs. |
| Horizontal condensing, 27-in. cylinder, . . . | 60 | $17\frac{1}{2} \times 21$ main valve, $5\frac{1}{2} \times 21$ cut-off valves, | 40 | $1\frac{1}{2}$ main, $1\frac{1}{2}$ cut-off, | Meyer expansion gear. Steel spindles. |
| Compound tandem vertical condensing, 20-in. high-press. cylinder, . . . | 80 | 11×20 main valve, 6×20 cut-off valves, | 54 | $2\frac{1}{2}$ main, $2\frac{1}{2}$ cut-off, | Meyer expansion gear. Spindles prolonged to work low-press. valves. Steel spindles. |
| 38-in. low-press. cylinder for above engine, . . . | ... | 21×28 main valve, $6\frac{1}{2} \times 21$ cut-off valves, | 32 | 2 main, $1\frac{1}{2}$ cut-off, | Meyer expansion gear. Steel spindles. Maximum pressure in valve chest 21 lbs. |
| Horizontal twin compound condensing, 20-in. high-press. cylinder, . . . | 120 | $18 \times 22\frac{1}{2}$ main valve, $13 \times 22\frac{1}{2}$ expansion valve, | 48 | $1\frac{1}{2}$ main, $1\frac{1}{2}$ expansion, | Hartnell's automatic expansion gear. Steel spindles. |
| 40-in. low-press. cylinder for above engine, . . . | ... | 48×33 main valve, 12×33 cut-off valves, | 105 | $2\frac{1}{2}$ main, 2 cut-off, | Double-ported Meyer expansion gear. Steel spindles. Maximum pressure in valve chest 30 lbs. |

| Description of Engine. | Boiler Pressure. | Extreme Dimensions of Valve in inches. | Distance from centre of Valve to Guide in ins. | Diameter of Valve Spindle at Stuffing Box in inches. | Remarks. |
|--|------------------|---|--|--|--|
| 20-in. locomotive, . { Horizontal twin compound condensing, 40 - in. high- press. cylinder, . . . | 170 { 90 | 11 x 19 { 37 x 35 main valve, 13 x 35 cut-off valves, | 53 { 123 | 2 1/4 { 3 main, 2 1/4 cut-off, | Simple slide valve. Steel spindle. Double - ported Meyer expansion gear. Steel spindles. |
| 74-in. low-press. cylinder for above engine, . . . | ... { | 54 x 62 main valve, 14 x 60 cut-off valves, | 123 { | 3 main, 2 1/4 cut-off, | Double - ported Meyer expansion gear. Steel spindles. Maximum pressure in steam chest 30 lbs. |
| 10-in. vertical engine, . . . | 60 | 6 1/2 x 9 1/4 | 17 | 1 | Simple slide valve. Steel spindle. |
| 18-in. horizontal engine, . . . | 50 | 8 1/2 x 16 | 30 1/2 | 1 1/4 | Simple slide valve. Wrought-iron spindles. |
| { Horizontal tandem compound, 19-in. high-press. cylinder, . | 70 { | 22 1/2 x 15 1/4 main valve, 5 1/2 x 15 1/2 cut-off valves, | 72 { | 2 main, 1 1/2 cut-off, | Meyer expansion gear. Steel spindles. Main valve spindle prolonged to work low-pressure valve. |
| 28-in. low-press. cylinder for above engine, . . . | ... { | 19 1/4 x 27 | 55 1/4 | 1 1/4 | Trick valve. Steel spindle. Maximum pressure in valve chest 20 lbs. |
| 13-in. locomotive, . . . | 120 | 8 1/4 x 11 1/2 | 48 | 1 1/4 | Simple slide valve. Yorkshire iron case- hardened spindle. |
| 10-in. locomotive, . . . | 130 | 7 x 8 1/4 | 45 | 1 1/4 | Simple slide valve. Yorkshire iron case- hardened spindle. |
| { Horizontal twin compound condensing, 18 - in. high- press. cylinder, . . . | 120 { | 16 x 7 1/4 main valve, 12 x 17 1/4 expansion valve, | 66 { | 2 main, 1 1/2 expansion. | Hartnell's automatic expansion gear. Steel spindles. |
| 32-in. low-press. cylinder for above engine, . . . | ... { | 33 x 27 main valve, 8 1/2 x 27 cut-off valves, | 87 { | 2 main, 1 1/2 cut-off, | Double - ported Meyer expansion gear. Steel spindles. Maximum pressure in valve chest 34 lbs. |
| 16-in. locomotive, . . . | 120 | 9 1/2 x 15 1/4 | 46 | 1 1/4 | Simple slide valve. Steel spindle. |
| 7-in. horizontal engine, . . . | 95 | 3 1/2 x 5 1/4 | 15 | 1 1/4 | Simple slide valve. Steel spindle. |
| 34-in. vertical engine, . . . | 65 { | 22 x 32 main valve, 17 x 32 expansion valve, | 66 { | 2 1/2 main, 1 1/2 cut-off, | Automatic expansion gear. Steel spindles. |

Valve Pins.—In consequence of the slight movement on the pins of ordinary valve gears a large surface pressure may be allowed. 1500 lbs. per square inch of surface is frequently taken, but this figure should be used with caution, and varied according to circumstances. Where the reciprocations exceed 500 per minute this pressure would be found too great, and 1100 would agree more closely with practice. The surface being understood to denote the length of the pin multiplied by the diameter, it follows that A being the area of the valve, P the maximum pressure of steam in the valve chest, μ the coefficient of friction, and p the surface pressure allowed, the surface of the pin will be—

$$\frac{AP\mu}{p}.$$

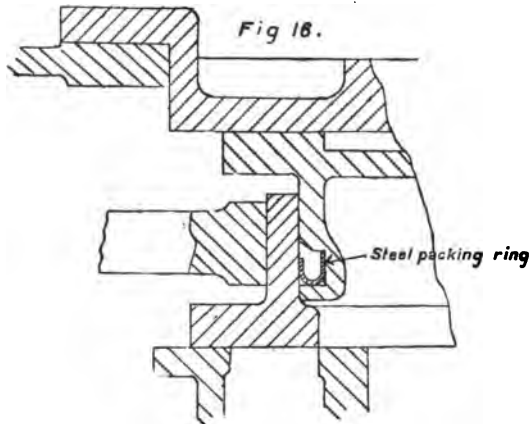
Also, if D and L equal the diameter and length of the pin, respectively,

$$D = \frac{AP\mu}{pL}; \text{ and } L = \frac{AP\mu}{pD}.$$

The proportion of D to L may be as 1 : 1.25. Then,

$$D = \sqrt{\frac{\frac{AP\mu}{p}}{1.25}}.$$

Balanced Valves.—The balanced slide valve is not regarded with much favour by many engineers, but there can be no doubt

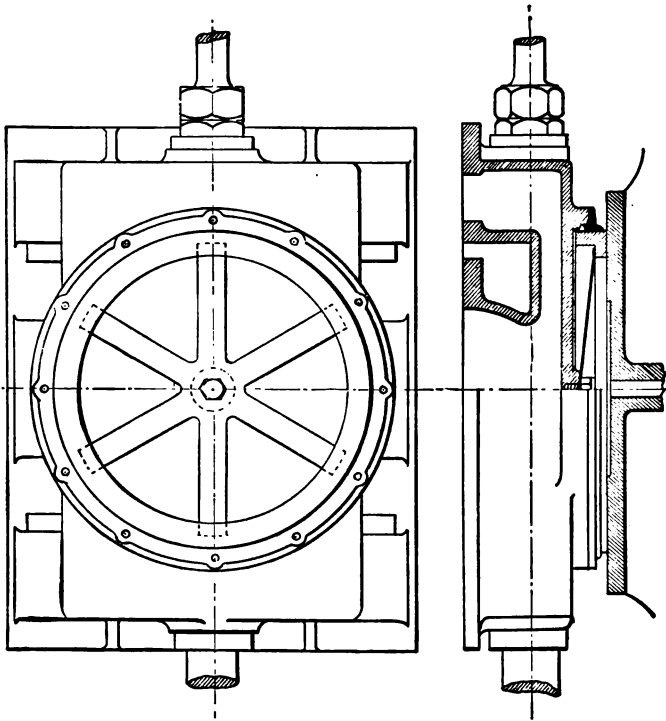


Common Form of Relief Ring.

that a well-designed and efficient arrangement is an advantage, particularly in large reversing engines operated by hand. To be a success, it is necessary that the relief rings and packings should be of the best workmanship, without which the appliance is worse than useless. Two common forms of relief rings are shown in Figs. 16 and 17.

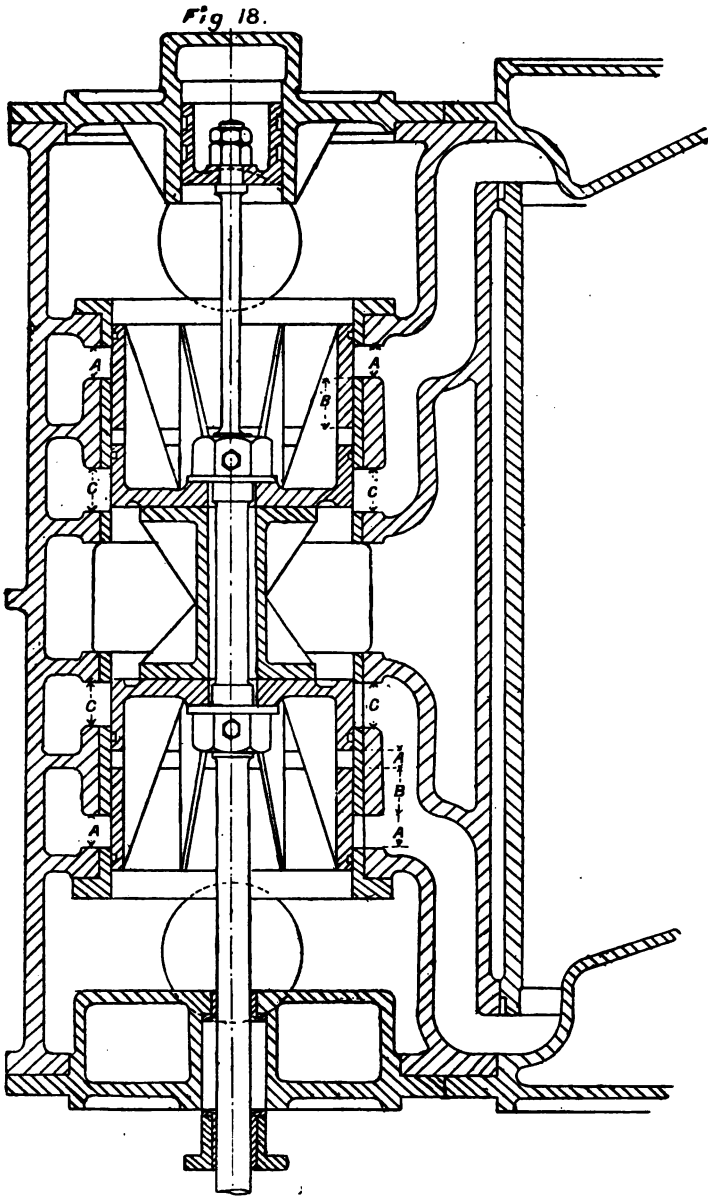
In practice it does not appear that the presence of a balancing ring reduces the diameter of the valve spindle to any appreciable extent; it being considered unsafe to rely upon the former relieving the valve, so that in the event of the relief ring becoming ineffective the engine may still be run with safety.

Fig. 17



Common Relief Frame.

Piston Valve.—A more effectual way of avoiding excessive friction of the valve gear is by the use of a piston valve. The first cost, however, is excessive, and its use entails large clearances. Fig. 18 is given as an example of a piston valve. The valve opens both ports for steam, but ~~one~~ only for exhaust. In this example packing is dispensed with. The pistons and working barrels are finished to inside and outside standard gauges. The barrels are forced into position, and secured by set screws to the main casting. When the pistons and barrels are thus carefully constructed, and have small grooves twined on the face, as shown in the figure, the escape of steam to exhaust will be so slight as to be immaterial.



Piston Valve.

The proportions of this valve are as follows :—

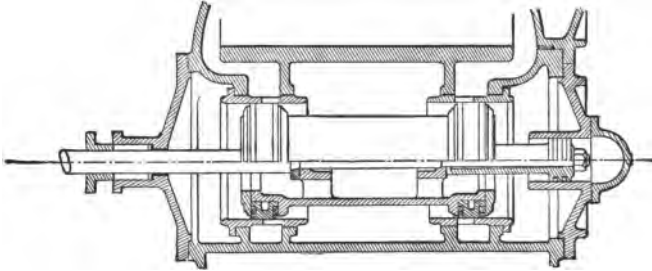
A = half required width of port opening for steam.

B = half travel of valve + (say) $\frac{1}{4}$ inch for tightness.

C = required width of opening for exhaust, which in this design must not be greater than the half travel of the valve.

Sometimes the steam enters between the pistons. In cases of this sort, the real position of the eccentric relative to the position

Fig 19.

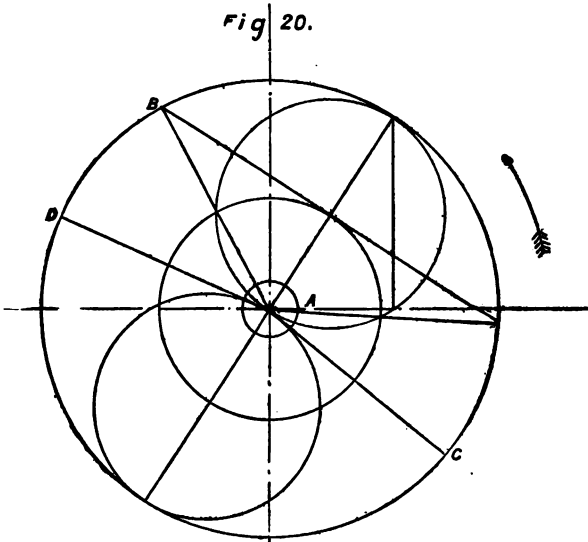


Common Piston Slide Valve.

of the crank, will be directly opposite the position indicated on the valve diagram; that is to say, the eccentric will follow, and not lead the crank.

In the above figure is shown another form of piston valve. The

Fig 20.



two pistons are part of a cylindrical casting carrying losses through

which the valve spindle passes, and to which it is secured. The packing of the pistons consists of metallic spring rings held in position by junk rings at each end of the valve. To prevent the rings springing into the ports diagonal bars are cast round the entrance of the latter. These bars, of course, contract the steam passage, and in calculating the area of steam and exhaust openings should be allowed for. The usual practice of having loose liners for the working barrels is followed; and the balance piston relieves the link motion of the weight of the valve, spindle, and other details.

The valve diagram is appended (Fig. 20), but as the construction is exactly similar to that of the slide diagram, it is unnecessary to enter upon an explanation. An inspection of the figure will show that cut-off is at A B—about 75 per cent.—and compression and release are at A C and A D respectively.

CHAPTER II.

SLIDE EXPANSION GEARS.

CONTENTS.—Expansion Gears—Diagram for Expansion Valves—Application of Ellipse Diagram to Expansion Gears—Valve Diagram—Design of Expansion Valves—Meyer Expansion Gear—Application of the Diagram—Expansion Regulator—Double-Ported Meyer Gear—Reynold's Valve Diagram, for Single Valve, and for Meyer Gear—Classes of Automatic Expansion Gear—Hartnell's Governor—Diagram for Hartnell's Expansion Gear—Application of the Diagram—Ruston-Proctor's Expansion Gear—Crank Shaft Governor Expansion Gear—Westinghouse Governor.

It has been remarked that for an earlier cut-off than $\frac{1}{2}$ stroke, an ordinary slide valve is not suitable. In order to obtain the efficiency of steam at pressures now common, it is necessary, even in compound engines, to cut-off at a much earlier point in the stroke than can be suitably effected by a single valve; and the problem of attaining the required degree of expansion without disturbing the proper points of release and compression presents itself. The mechanism employed to attain this end is termed Expansion Gear.

Expansion Gears.—Expansion gears may be classed under three heads:—1. Expansion gears in which the cut-off is fixed. 2. Expansion gears in which the cut-off is varied by hand. 3. Expansion gears in which the cut-off is automatically controlled by the engine through the operation of a governor.

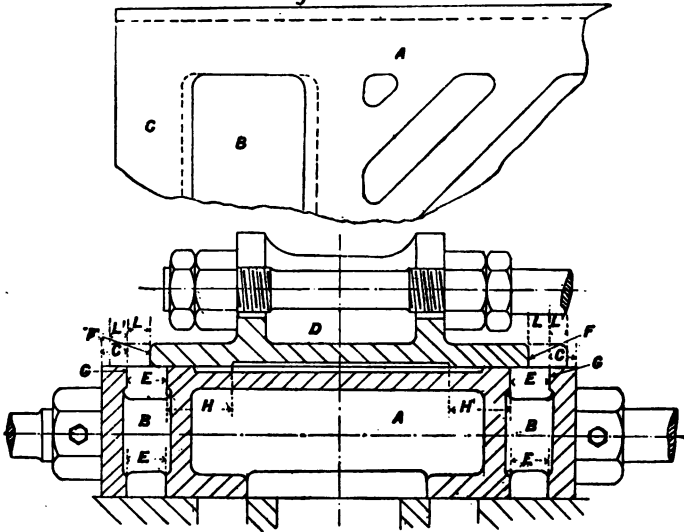
Fixed expansion gears are now little used, and are only suitable for engines having a definite and unvarying load, which condition is very rarely the case. However, as the consideration of this class embodies the principle of most expansion gears, it will be convenient to investigate it in the first instance.

In Fig. 21, A is a slide valve having steam ports BB formed at each end. This valve is virtually an ordinary slide, with the addition of the ribs CC, which form the outer side of the steam ports BB. Sliding upon the back of this valve is the expansion valve D, driven by a separate eccentric, the sole function of which is to control the admission of steam. It is easy to see that by arranging the eccentrics in a proper manner, the expansion valve can be made to slide past the outer edges GG of the ports BB, at any desired point in the stroke.

Diagram for Expansion Valves.—Before considering the expansion valve, the main valve must be designed. This is done

exactly as in the case of an ordinary slide valve. The width E equals that of the maximum opening to steam, as found by calculation. The width of the bar C is empirical.

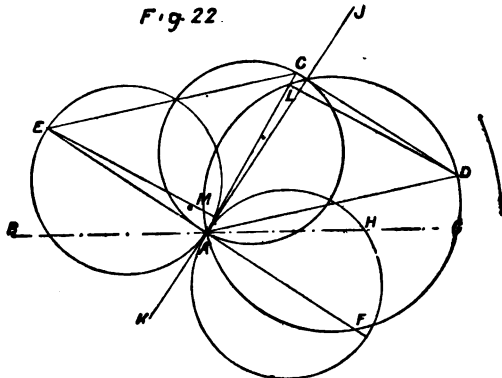
Fig 21.



Slide Expansion Valve.

In Fig. 22 let A B represent the position of the crank, and A C and A D the positions and throws of the main and expansion eccentrics respectively. Join C D, and draw E C equal and parallel

Fig 22.



to A D. Produce A E to F. On A E and A F, describe circles as shown. These are known as resultant circles; and in the manner in which the primary and secondary valve circles illustrate the

action of the simple valve, these resultant circles give the motion of the expansion valve relative to the main; and this relative motion is such as would be obtained by an eccentric whose throw and position are given by the line $A E$, when the main valve is supposed to be fixed, and in its central position.

In this instance the peculiarity of the Zeuner diagram is still present. The real position of the crank relative to the eccentrics, $A C$ and $A D$, is $A B$; but in tracing the action of the steam, the motion is supposed to be in the direction of the arrow.

In each diagram, unless there is a direct statement to the contrary, the arrow shows the *assumed*, and not the real direction of rotation.

The motion will now be traced throughout a complete revolution.

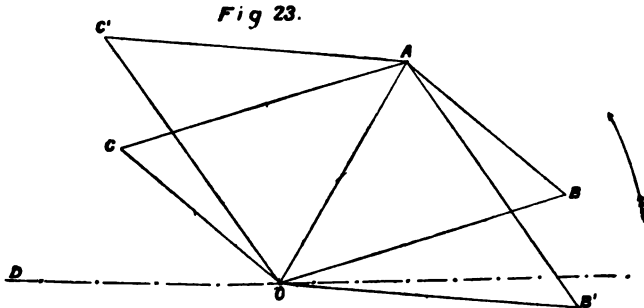
Starting at the beginning of the forward stroke, the assumed crank position being $A G$, the expansion valve will be distant $A H$ to the left of its central position on the main valve; which distance is given by the intersection of the crank position and the secondary resultant circle. The expansion valve continues to move from left to right until $A J$ is reached; at which point it arrives at its central position relative to the main valve; that is to say, the centres of the two valves will coincide, and will have, relative to one another, the position shown in Fig. 21; but Fig. 21 does not show their true position relative to the cylinder ports. $A J$ is at right angles to $A F$. The expansion valve now travels to the right of its relative central position until $A E$ is reached, at which point it attains the end of its relative travel to the right. At $A B$, the expansion valve is still to the right, as shown by the intersection of the crank with the primary circle. At $A K$, relative mid position is again reached; and when the crank is at $A F$, the valves are at their maximum distance apart. This displacement now decreases, and at $A G$ the revolution is completed.

In order to show that the resultant circles give exactly the action of the two valves relative to one another, draw on $A C$ and $A D$ the main and expansion valve circles. Take any position of the crank, say $A C$. The intersection of the crank line with the main eccentric circle $A C$ shows the distance of the main valve to the left of its central position on the ports, as explained above; and the intersection of the crank line with the expansion eccentric circle also shows the distance of the expansion valve to the left of its central position. The distance apart of the two valves relative to each other is obviously $C L$. The crank line $A C$ intersects the resultant circle in M , also showing the distance apart of the two valves. It remains to show that $A M = C L$. Join $E M$ and $D L$. Then, because $E A$ was made parallel and equal to $C D$, the angle $E A C$ is equal to the angle $A C D$; and the angles $E M A$ and $D L C$ are right angles and equal to each other (Euclid, Bk. iii., Prop. 31). Then, in the triangles $E M A$ and $D C L$, because the side $E A =$ the side $C D$ (by construction) and the angle $E M A =$ the angle $C L D$, and the

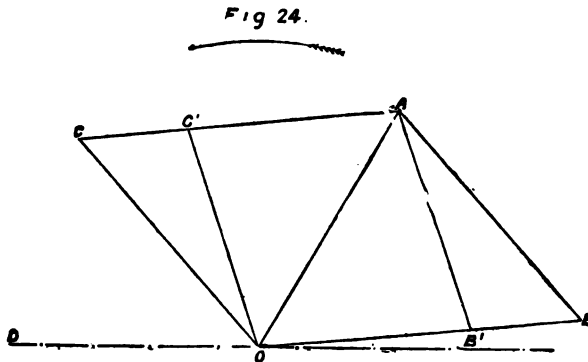
angle $EAM = \text{angle } LCD$, the side $AM = \text{the side } CL$ (Prop. 26, Bk. i., Euclid's Elements).

By reasoning similar to the above, the resultant circles can be shown to give exactly the relative positions of valves for all positions of the crank, and for any form of expansion gear operated by eccentrics in the ordinary manner.

Now, consider the effect of altering the throw and position of the expansion eccentric. In Fig. 23 let OA and OB represent the



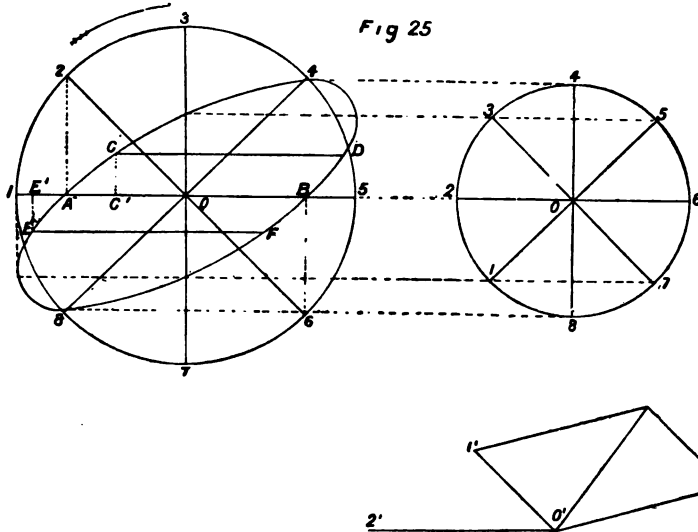
main and expansion eccentrics, and OD the real position of the crank. Then OO will be the line giving the resultant circles. Let the expansion eccentric be advanced to OB' . Then OC' is the centre on which the resultant circles are described. The expansion valve will therefore attain its central position on the



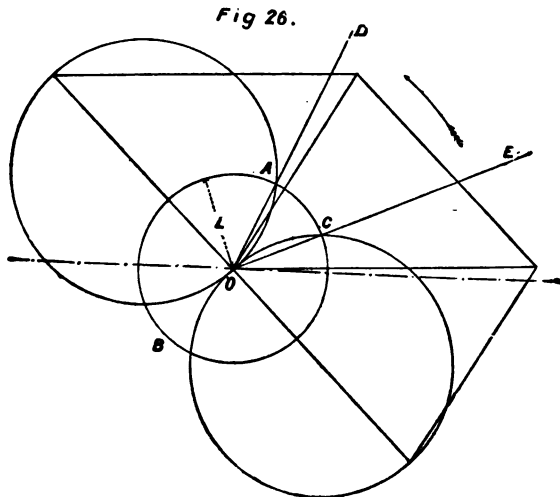
main valve earlier in the stroke, and the relative travel of the valves will be greater.

In Fig. 24 OD is the real position of the crank; OA is the main, and OB the expansion eccentric. OC is the centre of the resultant circle. Let the travel of OB be reduced to OB' . Then OC' will be the altered position of OC . The expansion valve will therefore attain its central position on the main valve earlier in the stroke, but the relative travel will be less.

Application of Ellipse Diagram to Expansion Gears.—
The resultant circles can be reduced to an ellipse. It will be seen



by an inspection of Fig. 25, that the angle of the centre line of the resultant circles is put back 90° from its real position in a similar



manner to the advance angle in the simple valve ellipse diagram. In the present figure, A and B are shown to be central positions; 4 and 8 extreme positions.

The effect of lap will now be considered. In Fig. 26, let L equal the dimension L in Fig. 21. From O , draw $O A D$. This line will represent the position of the crank when the expansion valve has closed the port in the main valve. Again, suppose L is positive. The expansion valve would then have the form shown by the dotted lines in Fig. 15; and L' (Fig. 21) would equal L (Fig. 26). Where the circle $A B C$ cuts the secondary resultant circle, draw the line $O C E$. This line is the position of the crank when cut-off takes place, the lap being positive. The following statements are deduced from the foregoing observations:—When the lap is positive, the point of cut-off is given by the intersection of the lap circle with the secondary resultant circle. When the lap is negative, the point of cut-off is given by the intersection of the lap circle with the primary resultant circle. When there is no lap the point of cut-off is given by a line at right angles to the centre line of the resultant circles.

In the valve ellipse diagram, if the lap be negative, draw $C D$ parallel to, and remote a distance equal to the lap, above the line 15. The line $C D$ crosses the ellipse at O . Then O' is the position of the piston at cut-off; 15 representing the whole stroke. Let the lap be positive. $E F$ is then the line that determines the point of cut-off, it being drawn below the line 15. E' denotes the piston position at cut-off.

Having premised these introductory remarks, the actual design of the valves will now be considered.

Valve Diagram.—On the diagram of the main valve draw the crank position when it is desired that the expansion valve shall cut-off. In Fig. 27, $O A$ is the line. The position and throw of the expansion eccentric are not determined by any exact construction. The travel is usually made greater than that of the main valve. $T \times 1.2$ is good practice; T being the travel of the main valve. As to the angle of advance, it has been shown that increasing this, increases the diameter of the resultant circles; so that other things being equal, the cut-off will be quicker. Hence, in practice, it is found that the angular advance is considerable. Eighty degrees in advance of the main eccentric is very suitable, but some makers have a constant angle, which in several cases is 90° ; that is, directly opposite the crank.

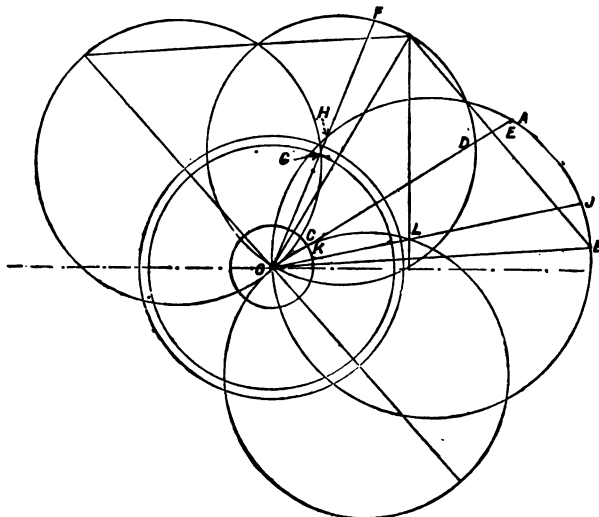
Let $O B$ (Fig. 27) represent the throw and position of the expansion valve eccentric decided upon. Draw the resultant circles. The secondary circle intersects $O A$ at C . $O C$ is the amount of positive lap on the expansion valve.

When the cut-off is nearly at right angles to the centre line of the resultant circles, it becomes difficult to see the exact point at which intersection takes place. If, however, a circle be described on the expansion eccentric line $O B$, the difficulty can be avoided; for the distance $O C$ is also given by the distance between the intersection of the main valve circle with the cut-off line, and the intersection of the expansion eccentric with the same line. In the

figure, D and E are the points of intersection ; and D E equals O C. Take another position, say O F. O G is the necessary lap, which is also given by H F. Here the lap is negative.

With regard to the port opening for any particular crank position, it is evident that when the lap is positive the port opening is given by the distance between the expansion valve lap circle, and the intersection of the resultant circle with the crank line. Thus, in crank position O J, the port opening is K L. But the actual port opening can never be greater than the width of the port

Fig 27.



through the main valve ; so that it would be more correct to say that K L is the distance of the edge F (Fig. 21) from the edge of the main valve port B. Suppose the lap O C is negative. Then the distance of edge B from edge G, would be L O + O K, for the crank position O J.

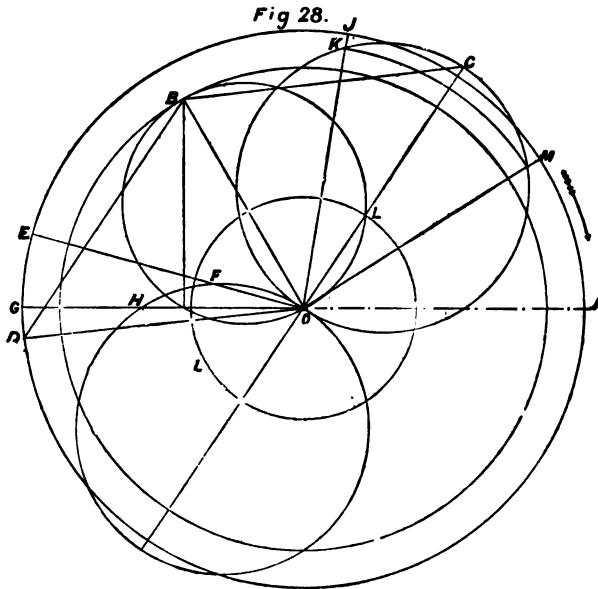
Design of Expansion Valves.—Referring now to Fig. 21, it will be noticed that the expansion valve is not machined the whole length of the face, but only for a width, H, past the edge of the port in the main valve. In order that steam shall not enter the port B from the inner edge of the face of the expansion valve, the distance H should be at least equal to the diameter of the resultant circles, which give the amount of relative motion of the two valves.

In expansion gears of this class, the cut-off should be equalised. The required adjustment cannot be found by Zeuner's diagram, but may be obtained by plotting down the crank and eccentric circles, and moving tracings of the valves into position for the front and back strokes. In practice this is seldom done. The valve spindle

is screwed past the nuts on each side, as shown in the figure, so that the cut-off may be adjusted when the engine is erected.

Meyer Expansion Gear.—Of variable hand expansion gears, the well-known Meyer gear is by far the most common. In this arrangement, a range of expansion is obtained by varying the lap of the cut-off valves.

In Fig 28, $O A$ is the real position of the crank relative to the main eccentric $O B$. $L L$ is the outside lap circle of the main valve, and cut-off occurs at $O C$. Decide upon the travel of the expansion valve, and from O as centre, and with radius equal to the throw of the eccentric, describe the circle $A E D$. Draw $B D$ parallel to $O C$; and join O and D . Then $O D$ is the position of



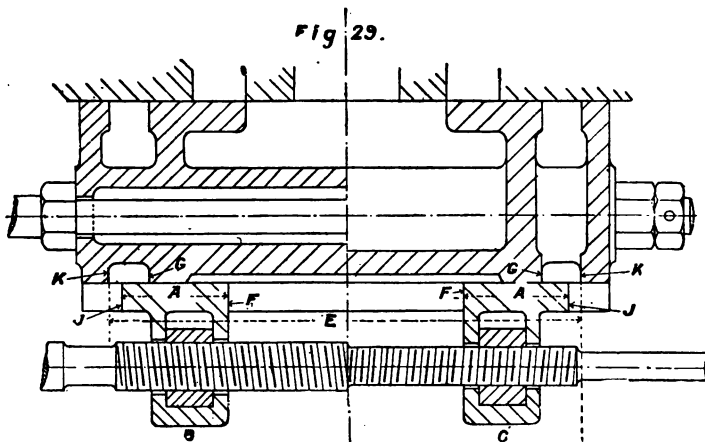
the cut-off eccentric relative to the position of the crank $O A$. By this construction the centre line of the primary resultant circle will coincide with the line of the main valve cut-off. The position $O D$ is not imperative; but for reasons which will be made known shortly, it is a most convenient setting.

Now, the nut of the expansion plate B (Fig. 29) being screwed by a right-handed thread, and the nut of plate C being screwed by a left-handed thread, the plates can be made to approach to or recede from one another, according to the direction of rotation of the valve spindle. This movement of the plates will alter the point of cut-off to any desirable extent.

Let the required range of expansion be from the beginning of the stroke, to the point of cut-off by the main valve.

To find the position of the expansion plates relative to the main valve, it is only necessary to draw the crank line for the required point of cut-off; for its intersection with either of the resultant circles determines the position. Take the position of the crank OE (Fig. 28). The line OE cuts the secondary resultant circle at F . OF is the required positive lap; or the amount that the edges J , of the plates B and C , overlap the edges K of the main valve, when B and C are central on the main valve, which position is shown in Fig. 29.

Take the point of earliest cut-off OG (Fig. 28). Here OH is the required positive lap. At the latest cut-off OC , the lap will be OC , and as OC intersects the primary resultant circle, it will be negative. It follows, therefore, that $OH + OC$ is the movement



Meyer Expansion Gear.

of each plate on the spindle, in order to vary the cut-off from OG to OC .

The reason for choosing OC for the centre line of the resultant circles will now be stated. At crank position OC the expansion plate will be at its extreme position to the right, relative to the main valve. But the negative lap necessary for this grade of expansion is equal to OC , so that it is evident the plate will re-open the port immediately after OC . The main valve, however, has cut-off at the same instant; therefore, re-opening by the expansion valve will not affect the efficiency of the gear. The latest possible cut-off by the expansion valve is given by the centre line of the primary resultant circle. When this centre line falls on, or after, the line of main valve cut-off, re-opening, as previously stated, is immaterial. For example, take a crank position OJ . OK will be the negative lap. The plate attains its extreme relative position at OC . It will now recede and re-open the port when OM is

reached, but as cut-off by the main valve has already occurred, this re-opening is of no consequence.

Application of the Diagram.—There is another way in which the port in the main valve may be re-opened, and that is by the edges F of the cut-off plates sliding past the edges G of the main valve.

Let P = diameter of resultant circles.

W = width of port in main valve (E in Fig. 29).

L = lap of expansion valve for earliest cut-off.

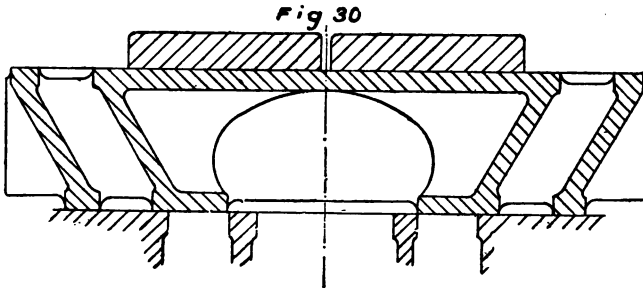
Then, in order to avoid this re-opening, the width A (Fig. 29) should be

$$P + W \pm L.$$

For positive lap take $+L$; and for negative lap $-L$.

It is necessary to add a little extra width to the dimension given by the foregoing expression to ensure tightness. A quarter of an inch will, in most cases, be sufficient addition.

The diagram shows that OC (Fig. 28) is the greatest negative lap. The dimension E in Fig. 29 must be great enough to allow of both plates being set to this negative lap. Therefore, E must not be less than $2A$ + twice the greatest negative lap. In some cases it may be necessary to slope the ports in order to obtain E. Fig. 30 illustrates a case in point.



Expansion Regulator.—In order that the spindle of the cut-off valves may be revolved to vary the expansion, it is prolonged through a stuffing box at the back of the valve chest; and has a wheel at or near the end of it. An index is usually provided, to indicate the grade of expansion. Fig. 31 shows a neat arrangement of cut-off regulator. In this design, the wheel is keyed on the brass sleeve A, the latter being mounted on the valve spindle by means of a feather key, thus permitting of a horizontal movement of the valve spindle, whilst the regulating wheel is at rest. The brass plate B is stamped, so that the finger correctly indicates the grade of expansion. The minimum length of the slot C in the regulator is given by the expression

$$T + \frac{MN}{n}$$

Where l = lead of main valve at each port.

W = width of cut-off plate.

N = lap at latest cut-off, which will, in most cases, be negative.

P = distance of cut-off valves from relative central position, when crank is on dead centre.

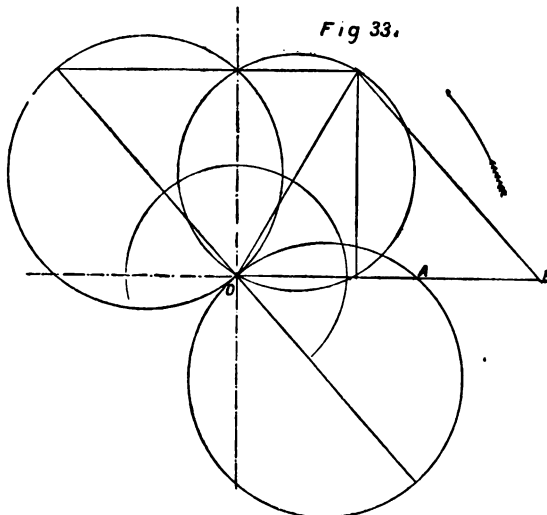
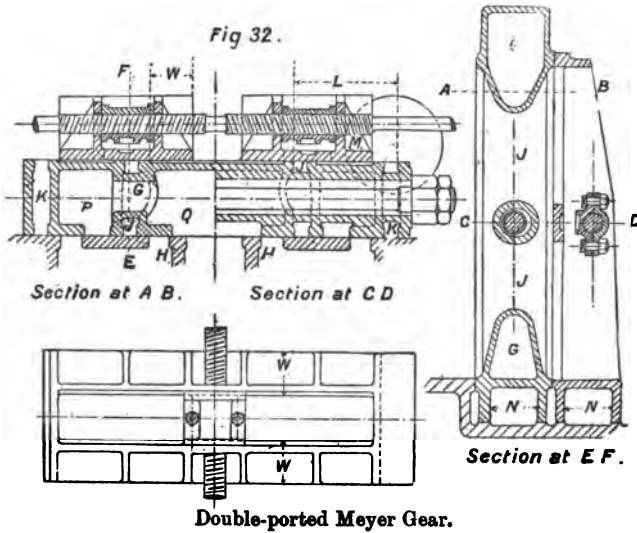
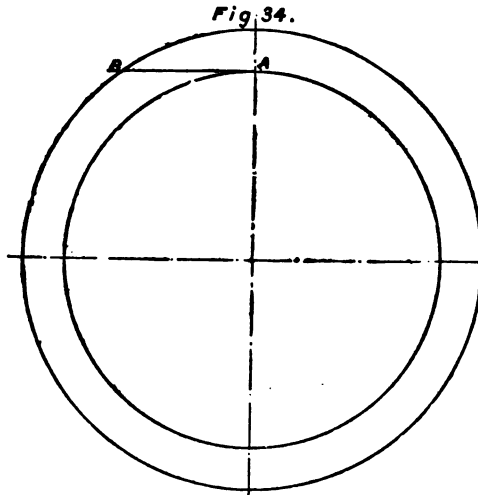


Fig. 33 is the diagram for the gear, and $OA = P$ in the foregoing expression, and is the distance of the cut-off valves to the left of the relative central position when the crank is at OB . The expansion

valve will open the port J at a quicker rate than the main valve will open to steam; which is as it should be. In every case, it is advisable to make L greater than the dimension given by the above expression.

The nuts of the expansion valves are shown divided. This permits of the valve spindle being kept the same diameter for each nut. The recess at the back of each nut is provided for the reception of a spring, which tends to keep the plate on the face of the main valve. In order that the spindle may be passed through the valve chest when the expansion plates are in position, it is necessary to have sufficient clearance to press back the back half of each nut, to clear the thread of the valve spindle. In Fig. 34, the inner circle represents the diameter of the valve spindle at the bottom of the thread, and the outer circle the diameter at the top of the thread.



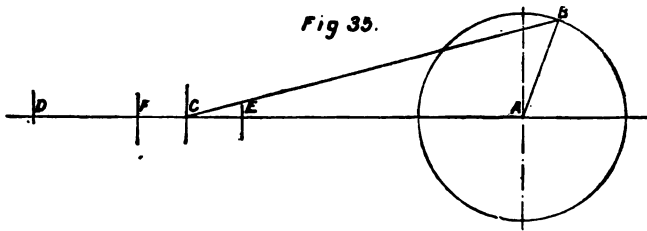
It will be necessary to push the nut back a distance equal to A B, before the spindle can be passed into position. When the steam chest is big enough to allow of the expansion plates being placed with their faces to the main valve spindle, the cut-off spindle can be passed, and the plates afterwards brought into their proper position. Then the above condition is not imperative.

The circle to the right of the plan view in Fig. 32 represents the steam inlet pipe. The main valve is, of necessity, of large size, and it was desirable to keep the steam chest as small as possible. Both the valves slide over the supply pipe, but in consequence of the deep feet N, the orifice is not obstructed to any serious extent.

With Meyer gears, when the cut-off is equalised for any one grade of expansion, it will not be equal for the other grades. In practice, it is usual to equalise the particular grade of expansion which corresponds to the normal load on the engine.

Reynold's Valve Diagram.—The action of the Meyer gear is very clearly shown by means of the Reynold valve diagram. It will be convenient to consider the diagram for a simple valve before treating of expansion gears.

In Fig. 35, *AB* represents the crank, and *BC* the connecting-rod of an engine. The piston-rod is suppressed; and therefore *D* and *E* are the extreme positions of the piston, and *F* is the central position. Divide the crank-pin circle into any number of equal parts; 36 divisions is the most suitable number. The corresponding piston positions for each of the crank-pin positions can be readily obtained. Thus, taking crank position *AB*, *FC* is the displacement of the piston from its central position.



Reynold's Valve Diagram.

Now, consider the line *AB*, in Fig. 36, to be the crank-pin circle of Fig. 29, drawn out into a straight line. Let this line be divided into 36 equal parts. Then each division will correspond to an angle of 10 degrees on the crank-pin circle. The distance of the piston from its central position, for each of these 10 degrees is obtained from Fig. 35, and transferred to Fig. 36; and a curve similar to *H K J* is obtained. The total breadth of the curve will be the stroke of the piston to the scale chosen. The piston is at its extreme position at *H*. At *D*, where the curve crosses the axis *AB*, the piston is in its central position, and the crank at 87 degrees from the starting point. *K* denotes that the end of the front stroke is attained. From *K* to *J* is occupied by the back stroke.

Reynold's Valve Diagram for Single Valve.—A similar curve must now be obtained for the valve. The extreme horizontal breadth of this curve will represent the travel of the valve. Any convenient scale for the breadth may be chosen, but the vertical axis of the curve must be the same length as the piston curve. Let the angular advance of the eccentric be 40 degrees. *O* on *AB* is the position for crank dead centre; so that if the valve curve cross the vertical 40 degrees before *O*, the curves will be in their correct position.

Take any position, say *L L*. The piston is distant *N O* from its central position; and at the same time, *N P* is the displacement of the valve from its central position. At *M M* the valve is at mid

position on the ports, and the intersection of MM with the piston curve indicates the then position of the piston. Let the outside lap be known. Draw CC parallel to AB , and removed a distance equal to the known outside lap from AB . Admission occurs at C . Draw CQ horizontally. Its intersection with the piston curve gives the piston position. This position may be projected vertically to a scale of percentages, and the position at once read off.

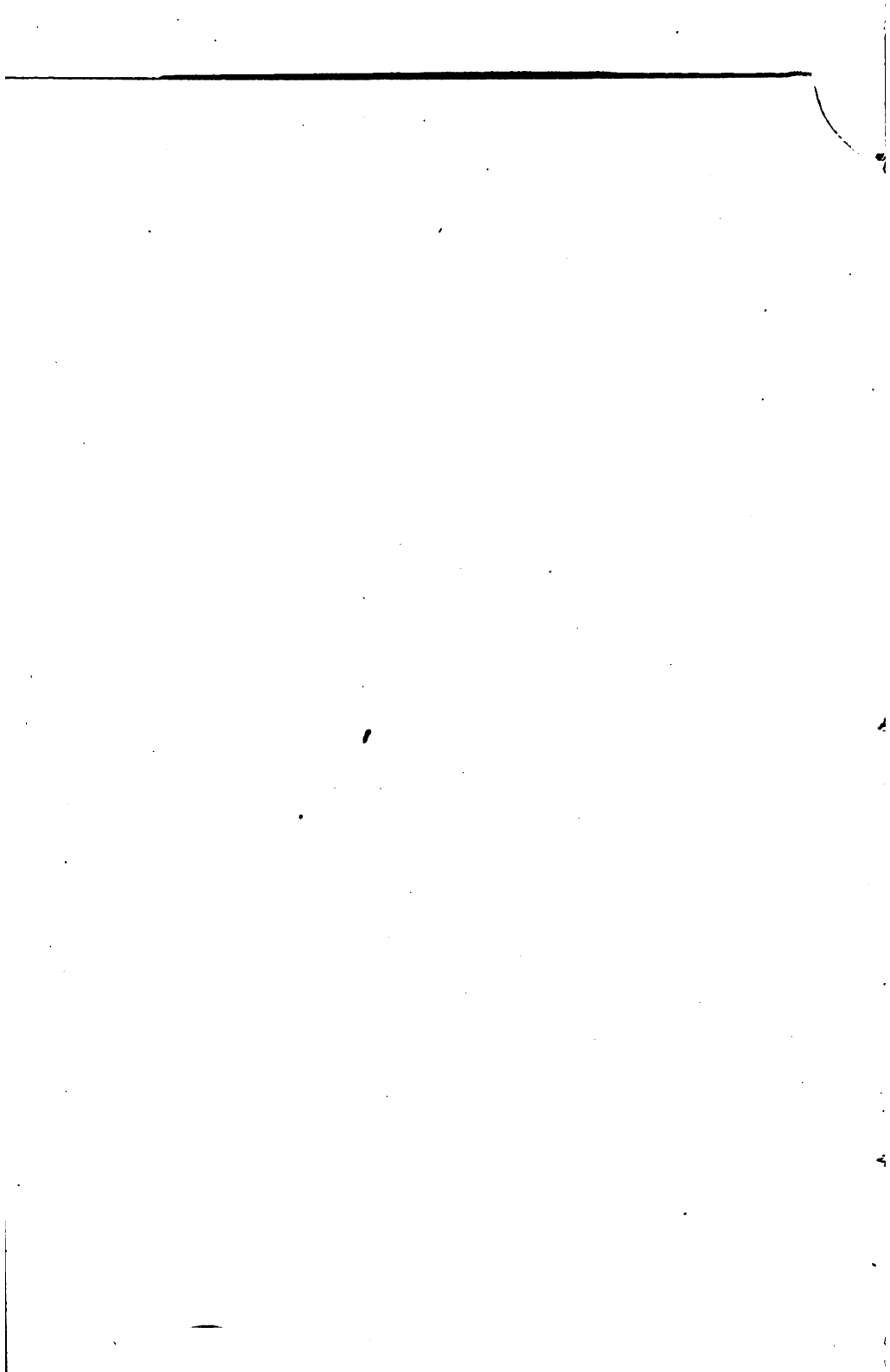
EE is a line parallel to AB , and G is the inside lap. Release is at E , and compression at E' . Let it be required that release shall occur at 93 per cent. in both front and back strokes. From 93 per cent. on the scale for the forward stroke, draw RS vertically, to intersect the piston curve at S . From S draw SF horizontally. Then, if the inside lap on the front end of the valve be equal to the distance between F and the vertical AB , release will occur at 93 per cent. From 93 per cent. on the scale for the back stroke, draw UV vertically, to intersect the piston curve at V . Project V horizontally, to intersect the valve curve at W . Then WX is the amount of inside lap necessary to release at 93 per cent. in the back stroke. If the intersection of these horizontals with the valve curve fell on the axis AB , no inside lap would be necessary; but if the intersections fell on the opposite side to EE' , negative inside lap would be required.

Reynold's Valve Diagram for Meyer Gear.—Take now the case of an expansion gear. Having, in the manner previously explained, obtained a curve for the expansion valve, it remains to connect this curve with the piston and valve curves in such a manner as will give the true positions of the piston, main valve, and expansion valve for any point in the stroke. It will be found convenient to plot down the main valve and piston curves on one sheet, and the expansion valve curve on a separate sheet of tracing paper, so that the latter may be set to any desired position, and the modifications effected by altering the angle of advance observed.

Fig. 37 shows the piston, main, and expansion-valve curves in position. The angular advance of the main eccentric is the same as in the previous case—namely, 40 degrees. The expansion-valve curve is placed for an angular advance of 90 degrees—that is, directly opposite the crank. A horizontal line drawn at any point of the crank-pin line AB , will give the then positions of piston and valves. And conversely, if any piston position be chosen, a vertical drawn from that position will intersect the piston curve, and a horizontal drawn from the intersection will give the valve positions.

Take the crank position CD . EF is the distance of the piston from its central position, and EH and EG will be the respective displacements of the main and expansion valves from their mid position.

Let it be required to cut off at 20 per cent. of the stroke. From 20 per cent. on the scale for the front stroke, draw the vertical to intersect the piston curve at J . From J draw the horizontal,

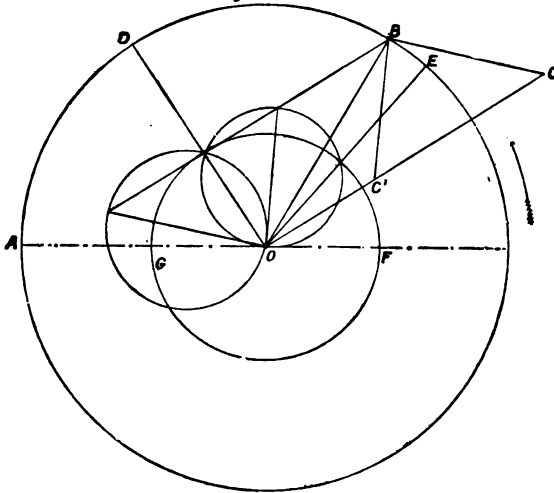


crossing the main and expansion curves at K and L respectively. K L is the necessary negative lap to accomplish this grade of expansion in the front stroke. From 20 per cent. on the scale for the back stroke, draw the line vertically, to meet the piston curve at M. From M, draw the horizontal, intersecting the valve curves at O and N. O N is the negative lap for the front end of the valve, to effect this grade of expansion. If the horizontals K J and M O crossed the curves at P and Q—that is, where P and Q cross each other—there would be no lap whatever; but if the verticals crossed on the opposite side of P and Q, the lap would be a positive quantity.

The equalisation of cut-off for any particular grade of expansion having been effected, it is easy to observe the inequality for the other grades; and herein lies the chief advantage of the diagram. The expansion-valve curve being drawn on a separate sheet of tracing paper, the angular advance may be altered by merely moving the position of the tracing; the effect of which is instantly manifested. This is another merit of the Reynold's diagram.

Classes of Automatic Expansion Gear.—Automatic expansion gears are made to vary the cut-off:—1. By varying the travel

Fig. 38.



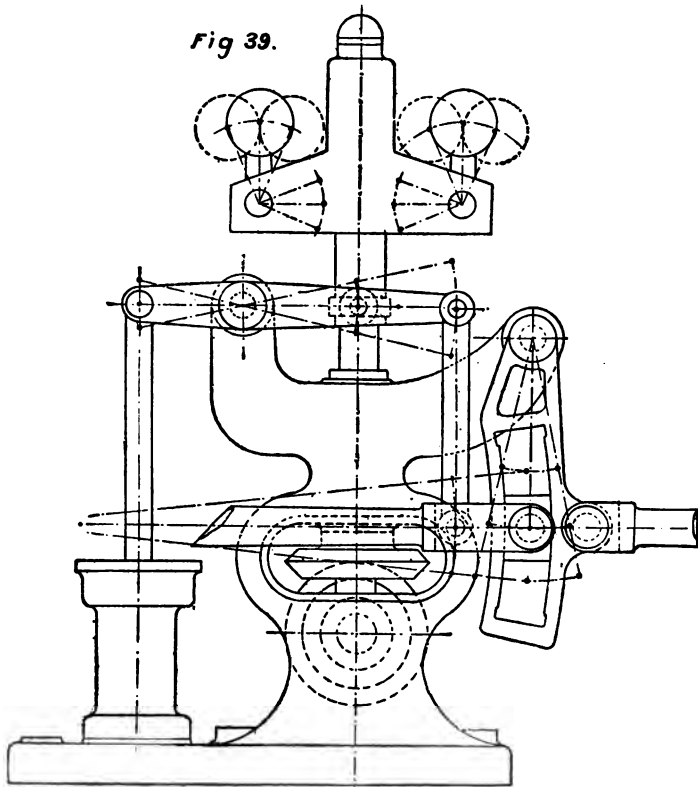
of the expansion valve. 2. By varying the angular advance of the expansion eccentric. 3. By varying both angle and travel of the main eccentric.

In Fig. 38, OA is the crank, OB the main eccentric, and OC the expansion eccentric. Let the circle FG be drawn with radius equal to the negative lap. Cut-off will occur at crank position OD . Now, suppose the throw of OC to be reduced to OC' . Cut-off then

occurs at O E. This diagram illustrates the principle of expansion gears of the first class.

Hartnell's Governor.—Fig. 39 is a sketch of the well-known Hartnell governor combined with a link expansion gear. When the engine is running at the normal speed, the die in the swinging link occupies the position indicated. When an increase of speed takes place, the balls fly out, raising the radius rod, which shortens the travel of the expansion valve. Cut-off will therefore be earlier in the stroke. When the speed falls below the normal, the radius

Fig 39.



Hartnell's Governor.

rod is lowered. This action increases the valve's travel, and cut-off is later. The governor itself is a spring-loaded one. Between certain limits, any desired speed may be maintained by adjusting the helical spring in the head.

Diagram for Hartnell's Expansion Gear.—No exact construction can be given to determine all particulars of this gear. Generally, the positions of the crank at early and late cut-off, and the maximum and minimum travels of the expansion valve would

be decided upon. But it is necessary to assume either the angular advance or the lap of the expansion valve before a diagram can be constructed.

Let OE , Fig. 40, be the line of latest cut-off in relation to the crank position ON revolving as shown; OA the throw and position of the main eccentric, and OB and OB' the throws and position of the expansion eccentric for maximum and minimum travels respectively. OC is the resultant circle corresponding to OB ; and OD the resultant circle for OB' . OE intersects the resultant circle for maximum travel, at F . OF is the required negative lap. Draw the negative lap circle FG , intersecting the resultant circle for minimum travel at G . OH is the position of the crank at earliest cut-off. It may be that this range of expansion

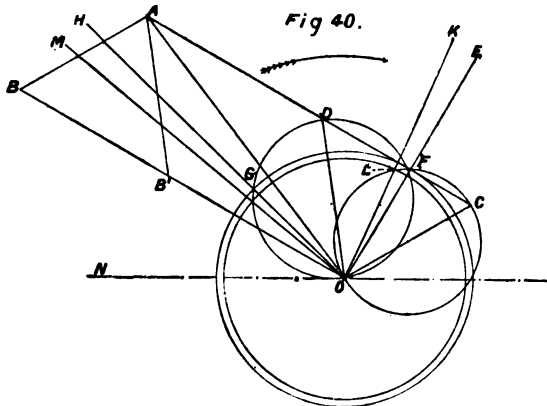


Diagram for Hartnell's Expansion Gear.

is not sufficient. Decreasing the negative lap would not alter the total range of expansion, as far as the cut-off valve is concerned, but would cause OE and OH to fall earlier in the stroke. But OK is the cut-off by the main valve. OE can be made to coincide with OK , by giving negative lap OL . This will alter OH to OM ; which alteration has increased the actual range of expansion by the angle HOM . Decreasing the angular advance of the expansion eccentric would also increase the range of expansion, as may be shown by construction.

Application of the Diagram.—The valves for the Hartnell gear may assume the form shown by Fig. 41, the proportions being as follows :—

The sum of the width of the ports C , may be equal to one and a-half times the width of port E , to ensure a good steam line.

$$A = D + C - L, \text{ + say } \frac{1}{4}\text{-inch for tightness.}$$

Where D = diameter of largest resultant circle.

C = width of port (see Fig. 41)

L = negative lap.

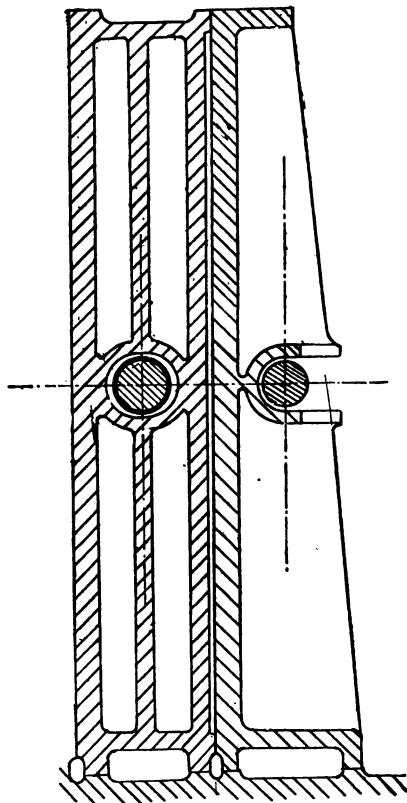
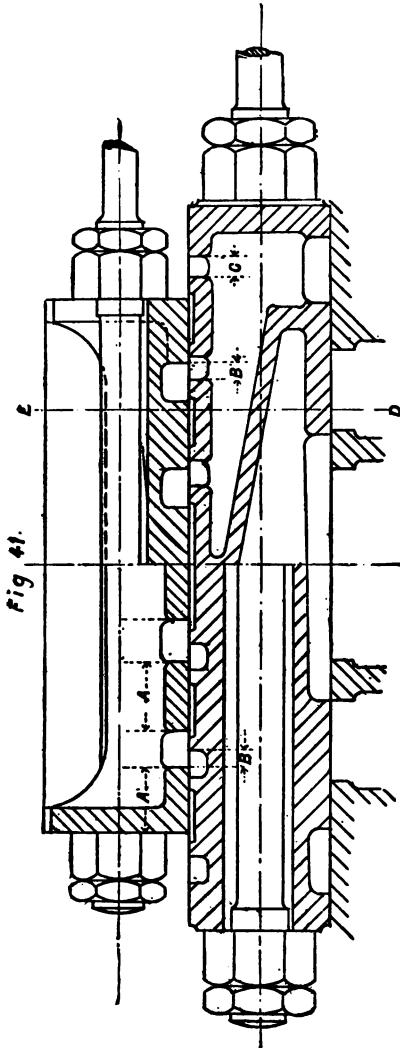
Note. — L would become $+L$ if lap were positive.

B should be not less than $\frac{L}{N} + D$.

Where L = lead of main valve.

N = number of ports on each side of expansion valve.

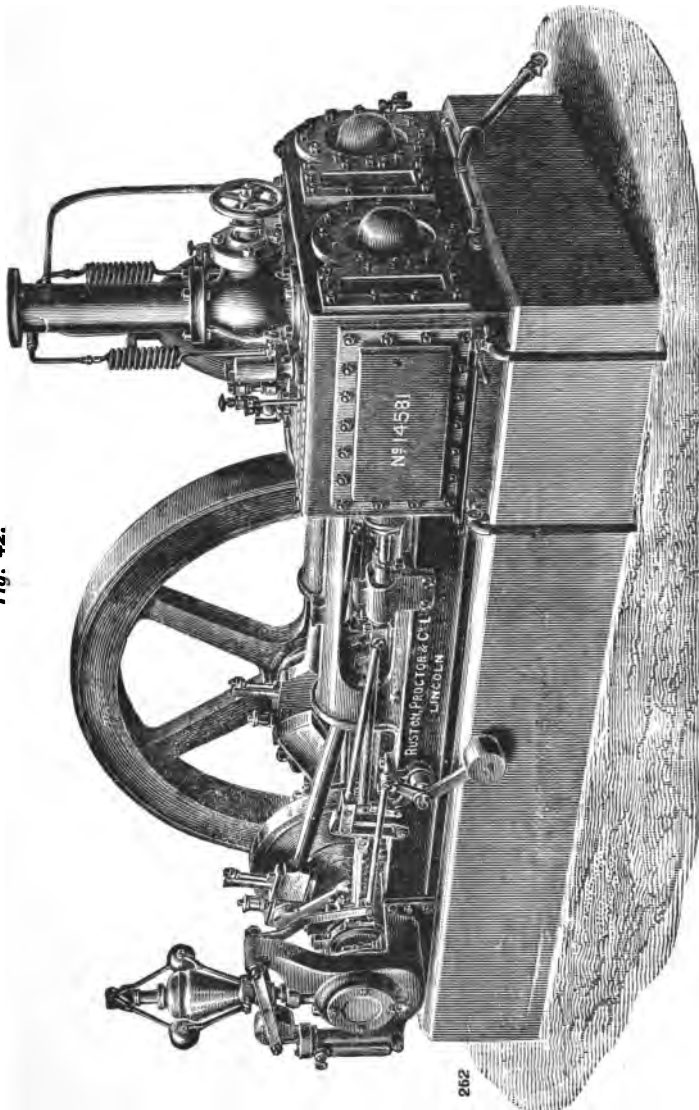
D = greatest distance of expansion valve from its relative central position, when crank is on dead centre.



Section through D E.

In practice, B would be found to exceed the dimension given by the above expression. The ports are often divided equally along the face of the valve. The rules just given can then be employed to ascertain whether the action is satisfactory or not.

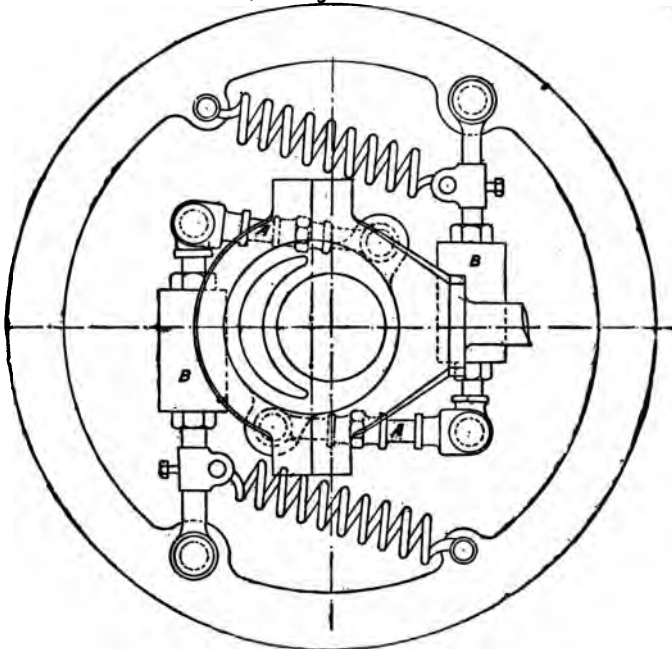
Fig. 42.



Automatic Expansion Gear.

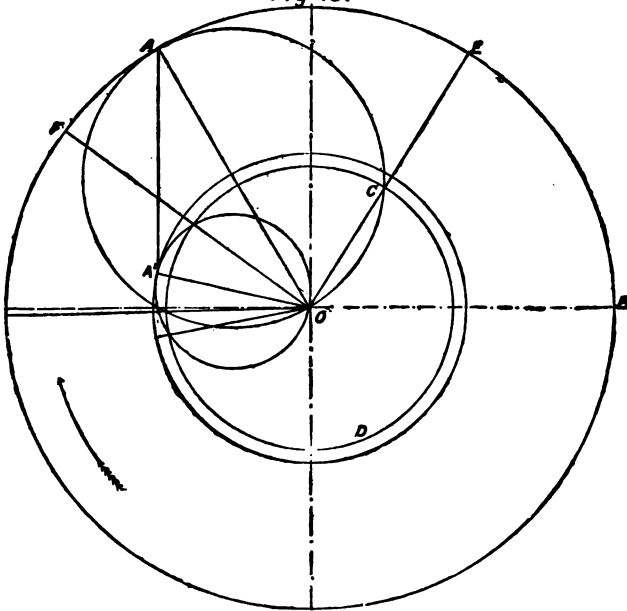
Fig 44

49



Crank-Shaft Governor Expansion Gear.

Fig 45.

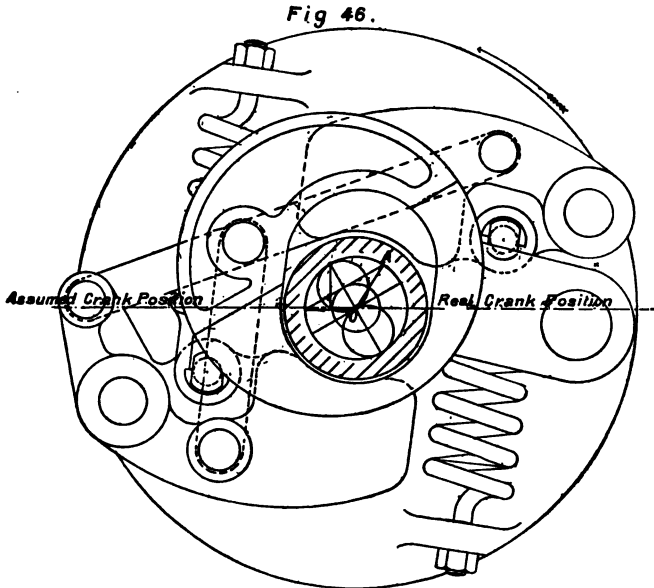


means of the nuts on the levers ; and the connecting links A A are also adjustable.

The third method of obtaining a range of expansion is by varying both the throw and position of a simple slide valve eccentric. The principle of this class of gears is set forth in the accompanying diagram.

Let OA (Fig. 45), represent the throw and position of the eccentric relative to the true position of the crank OB. CD is the outside lap circle, and cut-off is at OE. Let the eccentric be altered so that its throw and position are given by the line OA. The lap circle will remain the same, and the cut-off will therefore be at OF.

Westinghouse Governor.—As a typical example of this class of gears, the Westinghouse governor and eccentric is selected.



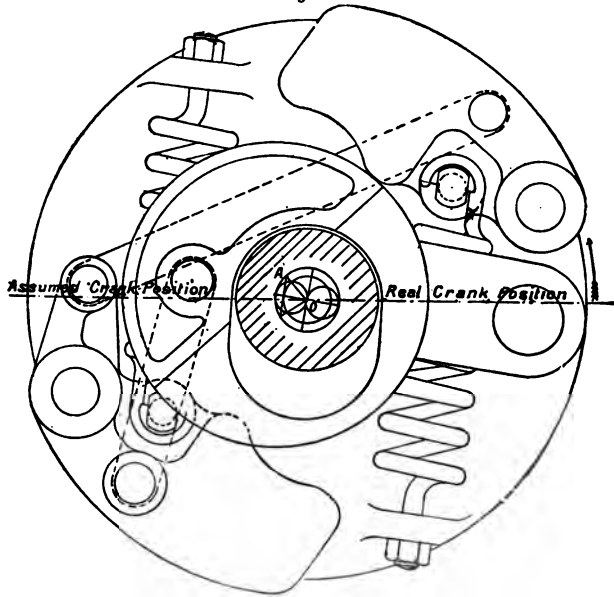
Westinghouse Governor (position for latest cut-off).

Fig. 46 shows the position of the parts for the latest cut-off, which is at OA. In Fig. 47 the gear is in position for earliest cut-off, which is at OA. The real and assumed crank positions are indicated on each figure, as is also the direction of rotation. The valve diagrams show that as the governor moves from latest to earliest cut-off, the lead increases. This governor operates upon a piston valve, which is the most suitable form for crank-shaft governors, as the work required to move the valve passes partly through the springs.

Crank-shaft governors find much favour in America. The

Dick and Church governor, as made by the Phoenix Iron Works Company, is representative of its class.

Fig 47.



Westinghouse Governor (position for earliest cut-off).

The principal forms of slide valve expansion gears have now been dealt with. The varieties and modifications are numerous, but the action is generally little different from the gears that have been described, a knowledge of which will enable the action of other gears to be understood.

CHAPTER III.

LINK MOTIONS.

CONTENTS.—Single Eccentric Reversing Gear—Valve Diagram for shifting Eccentric Gear—Stephenson's Link Motion—Open and Crossed Rods—Valve Diagram for Stephenson's Link Motion—Mr. Macfarlane Gray's method of describing the Characteristic Line—Crank Pin Diagram—Best arrangement of Gear—Link Motion made by the North-Eastern Railway Company—The Slot Link—The Double bar Link with Eccentric Rods inside—The same with Eccentric Rods outside—Proportions of Links—Gooch's Link Motion—Eccentrics driving obliquely—Valve Diagram for Gooch's Link Motion—Crank Pin Diagram—Best arrangement of Gear—Allan's Straight Link Motion—Diagram for Allan's Gear—Expansion Gears and Link Motions combined.

To enable an engine to run in either a forward or backward direction, it must be fitted with link motion, or some other equivalent device; and it remains to discuss various gears by means of which reversal is effected.

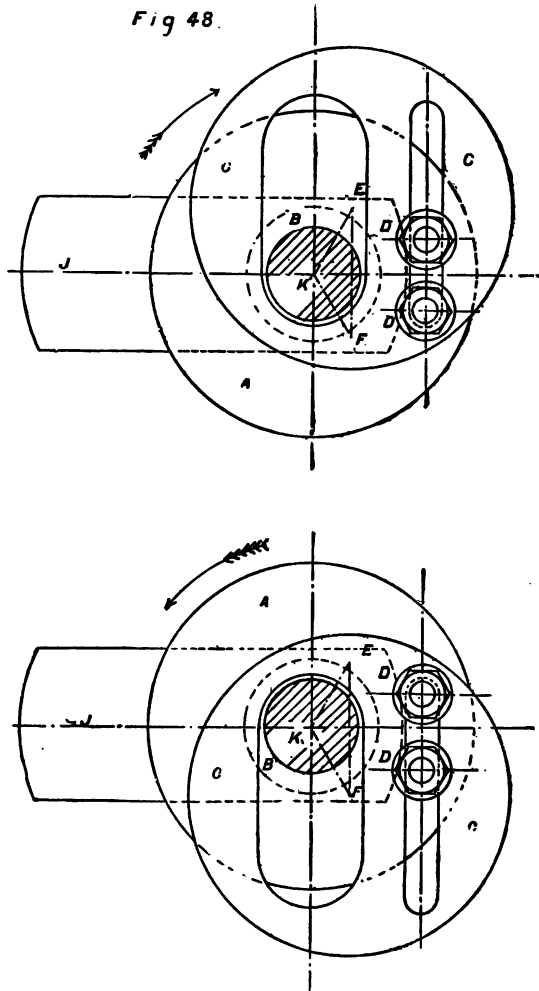
Single Eccentric Reversing Gear.—The simplest form of reversing gear consists of an eccentric, the angle and throw of which can be varied at will by moving it across the shaft. This device, although simple and efficient, would be very inconvenient, especially on an engine of large size, or on one that required frequent reversal; and the arrangement is here described, not because of its practical utility, but because of the principle involved—the principle of link reversing gears.

The single eccentric reversing gear consists of a plate A, secured to the crank shaft B by means of a key. The eccentric C is provided with two slots, whereof the larger is to allow of the eccentric being moved on the shaft, so as to take either the position shown by the upper or lower diagram, Fig. 48, or any intermediate position between the extreme limits. The second slot is made to pass the bolts D D, which are securely fixed in the plate A. This arrangement permits of the eccentric being held in any position between E and F.

In the diagram the position of crank is indicated, and also the centre line of the eccentric. It will be understood that when the eccentric is secured so that it coincides with the line K E—its extreme position in one direction—the engine will run in the direction of the arrow, and when the eccentric has the position K F, the motion is reversed. The reason of this is clear. Consider first the upper diagram, where the crank is on dead centre, and the line K E is the position of the eccentric. The cylinder is supposed to lie to the left of the figure. Motion by piston effort

at this position is, of course, impossible, but suppose the crank moved by some means in the direction of the arrow. The eccentric moves through the same angle in the same direction. This movement will manifestly drag the valve spindle, and consequently the

Fig 48.



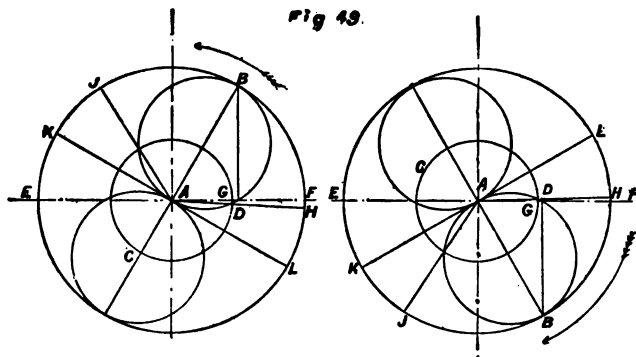
Single Eccentric Reversing Gear.

valve, from the back end of the steam chest towards the front end. When the crank is at the back dead centre, KJ, the eccentric, if correctly set, will have opened the back steam port for lead, and any movement of the crank in the arrow's

direction will cause the port to be opened wider. The engine would therefore run in the direction indicated, or "over," as it is commonly termed. If the crank were moved in the opposite direction, the eccentric still being held in the position K E, the valve would have the back port open to lead as before, but motion of the eccentric in that direction would close the port, thus preventing the engine running "under."

Now consider the action when the eccentric coincides with the line K F, which position is shown in the lower figure. The crank may be supposed to be on dead centre as before. Any movement in the arrow's direction opens the back port wider; and the engine is therefore free to revolve in a counter-clockwise direction. Moving the crank in a direction opposite to that indicated would close the back port, thus preventing clockwise running.

Valve Diagram for Shifting Eccentric Gear.—The Zeuner valve diagram is well adapted to the solution of problems in



Zeuner Diagram.

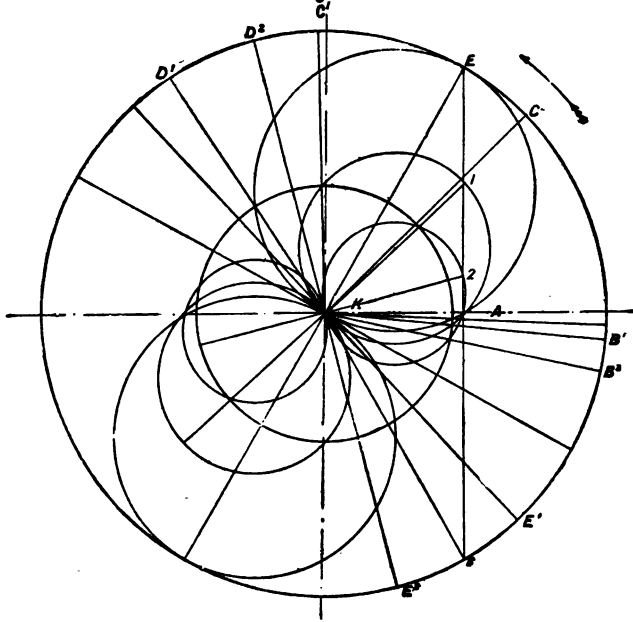
connection with the shifting eccentric gear.* Let A B represent the position of the eccentric when set for running in the arrow's direction. A B in the left-hand diagram of Fig. 49 is, in fact, the line K E of the upper diagram in Fig. 48, and A B in the right-hand diagram (Fig. 49) is the line K F in the lower diagram (Fig. 48). On A B describe the polar valve circle. From B draw B D perpendicular to the horizontal E F, and mark off the lead D G. A G is therefore the amount of lap. Draw the lap circle G C. Admission, cut-off, release, and compression are at A H, A J, A K, and A L respectively.

The inherent peculiarity of the Zeuner diagram is here seen. The *real* position of the crank relative to the eccentric's position A B, is A E; but the steam distribution is traced round in the direction indicated, as though the crank were *leading* the eccentric.

* This matter has already been touched upon when dealing with crank-shaft governor gears.

The state of things for any position of the eccentric between E and F (Fig. 48) can now be shown. KE and KF in Fig. 50 are in length and position equal to KE and KF of Fig. 48. Join E and F. The line EF represents the path of the eccentric sheave when being moved from one extreme position to the other. Wherever the position of the eccentric may be, the line EF must terminate the radius of the eccentric throw, and, therefore, the line drawn for any intermediate position of the eccentric on the line EF, to the centre K, represents by its throw and position the radius and angle of the eccentric sheave; and if on that line

Fig 50.



produced, valve circles be drawn, the action of the steam is rendered clear. In the accompanying figure this has been done. Two intermediate points have been taken and numbered 1 and 2. Admission, cut-off, release, and compression are at $B^1, B^2; C^1, C^2; D^1, D^2; \text{ and } E^1, E^2$, respectively.

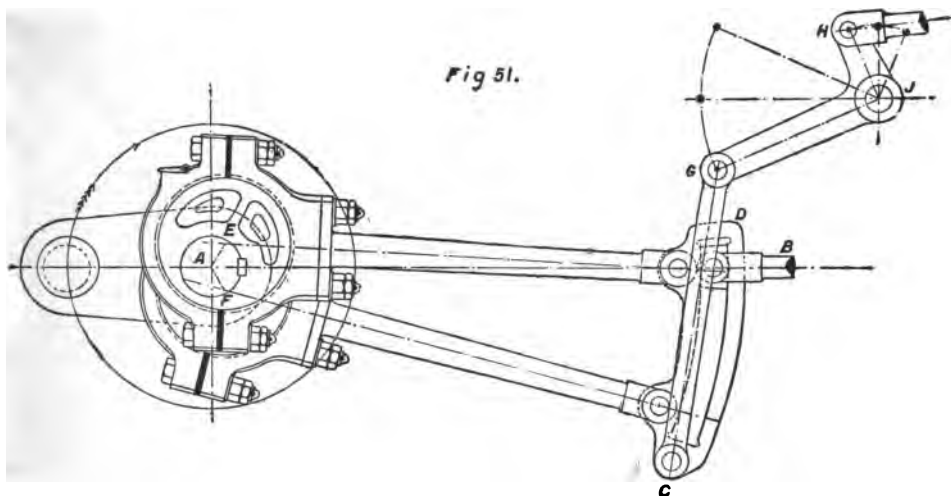
Tabulating these results it appears that—

| | | | | |
|---------------------------------|---|----------------------|---|---------------------------------------|
| When the eccentric is at K 1 | { | Admission is earlier | { | than when the eccentric is at K E. |
| | | Cut-off | | |
| | | Release | | |
| | | Compression | | |
| When the eccentric is at K 2 | { | Admission is earlier | { | than when the eccentric is at K 1. |
| | | Cut-off | | |
| | | Release | | |
| | | Compression | | |

It also appears from the diagram that, although admission is earlier as the eccentric approaches its neutral position $K A$, the lead is constant for all positions, because the cosine of the eccentric angle is constant. This is true, neglecting the angularity of the eccentric-rod, which is generally so small as to be quite inappreciable.

The line $E F$ will be designated the characteristic line of the gear, and it will be shown that in certain forms of reversing gears it is a straight line, as in the present instance; and in others it has a curvature, sometimes towards the crank shaft, and sometimes towards the cylinder. The significance of the various forms will become apparent as the work proceeds. For the present it will suffice to say that when the characteristic line is straight and vertical, the lead is constant for all positions of the gear.

Stephenson's Link Motion.—Fig. 51 shows the well-known Stephenson, or shifting link, motion. $A E$ is the throw and position



Stephenson Link Motion.

of the eccentric for running under, and $A F$ the eccentric for running in the reverse direction. The link $D C$ is curved with a radius equal to the length of the eccentric-rods,* and is concave to the crank shaft. The valve spindle B is coupled to the link $D C$ in such a manner that the latter is capable of being raised or lowered

* When the length of the eccentric-rods is spoken of, it should be understood to denote the distance from the centre of the eccentric clips to the centre of the eccentric pin holes on the link, unless there is a direct statement to the contrary. Strictly speaking, the form of link shown in the figure has a radius greater than the length of the eccentric-rods, by the distance between the eccentric pin hole and the pin hole in the link block, when in full gear.

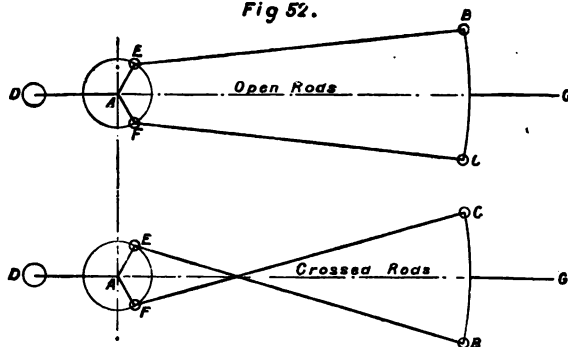
by the lifting link CG , which is in turn connected to the bell-crank lever GH , having J as a fulcrum. This lever may be operated by a reversing handle, a reversing wheel and screw gear, or by a small cylinder fitted for the special purpose. The latter arrangement constitutes what is known as a "steam reversing gear," and is most frequently seen on large winding engines.

In the diagram the eccentric AE has sole control of the valve, the action of which is similar to that of a valve connected to the eccentric AE in an ordinary manner. The crank, therefore, revolves in the direction indicated. The angle and throw of the eccentrics are determined by the construction of a diagram similar to that illustrated in Fig. 1. When the eccentric AF has control of the valve the action is practically the same, but the motion of the crank is reversed.

The action of the motion for full forward and full backward gear being understood, the question arises, what would be the action for any intermediate position of the link block?

Open and Crossed Rods.—Before dealing with this question, the meaning of the terms "open" and "crossed" rods should be

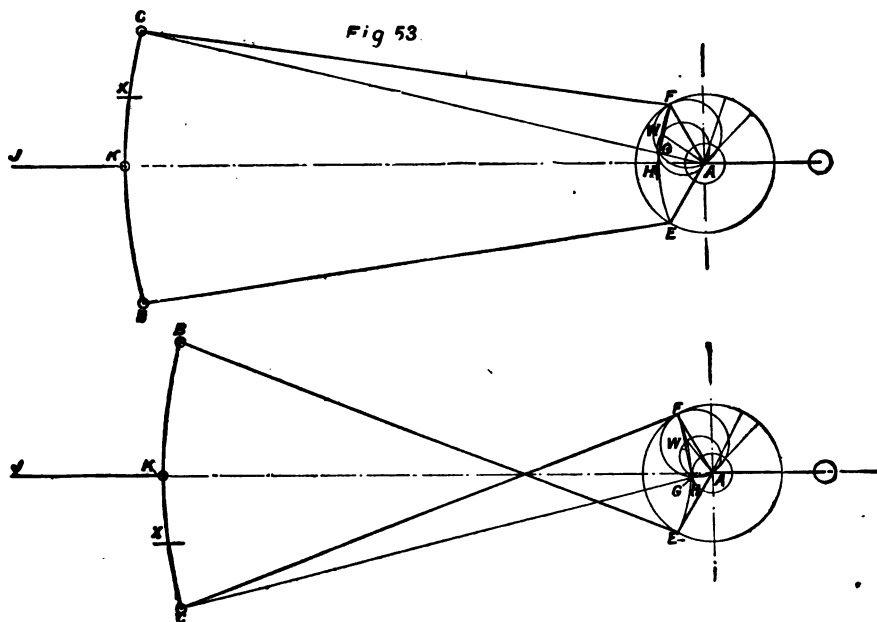
Fig 52.



made clear. In Fig. 52 AE and AF are respectively the forward and backward eccentrics of a link motion driving a valve spindle G . In the upper figure the eccentric-rods are coupled to the link on the side on which are situated the respective centres of the eccentric sheaves, when the crank is on the outer dead centre. This arrangement constitutes an "open" rod link motion. In the lower figure the eccentrics are coupled as shown, thus forming what is known as a "crossed" rod link motion.

Valve Diagram for Stephenson's Link Motion.—Let AE and AF , Fig. 53, be the forward and backward eccentrics, respectively, of two link motions, whereof the upper diagram is an open, and the lower a crossed rod arrangement. BC is the link, and FC and EB are the eccentric-rods. On AE describe the valve circle, cutting the line AC , which is drawn from the extremity of the link C , to the centre of the crank shaft in G . From F through the point

G, draw the straight line FH , meeting the horizontal line AJ in H . Through the three points E , H , and F draw an arc. This arc will be the characteristic line of the gear, and includes the extremities of all the virtual eccentric arms for any position of the block in the link. Take any position of the gear, and divide the line EF in the same proportion that the block divides the whole length of the line. Referring to the diagrams, let X be the point of gear chosen. It is required to find the movement of the valve corresponding to this particular position. On the characteristic line EF mark the point W so that FW bears the same proportion



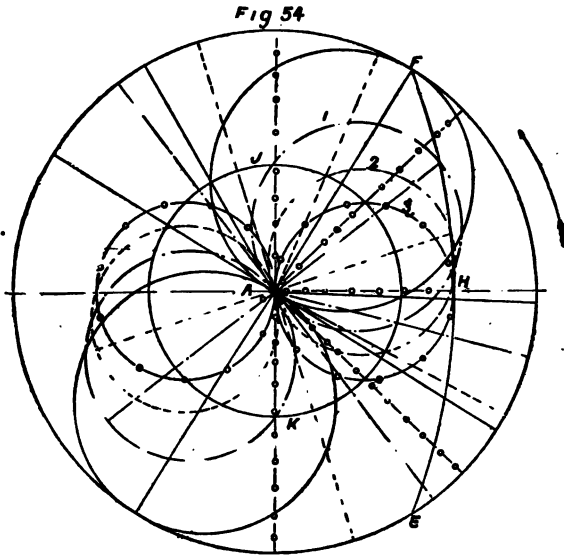
Valve Diagram for Stephenson's Link Motion.

to the line EF that XC bears to the whole length of the link CB . Join the points A and W . Then, AW is the virtual eccentric arm which produces approximately the same valve movement that results from the combined action of the two eccentrics AE and AF , acting through the medium of the link BC . On AW as diameter draw the valve circle. The maximum port opening, the periods of admission, cut-off, release, and compression are now clearly seen; and by choosing other positions of the link and repeating the above construction the action for any other point is seen.

Consider the enlarged diagram for open rods, Fig. 54. The letters A , E , F , and H correspond with the letters of the previous diagrams;

and the characteristic line EF contains the extremities of all the virtual eccentric arms. The lap circle JK remains constant for all positions of the gear; the valve circles, however, are changed for every position of the gear, and cross the lap circle at different points, and, in the manner of the simple Zeuner diagram, indicate the percentages of admission and cut-off. The lead is also seen to vary for all positions of the link, a fact which explains that common statement that in the shifting link gear, with open rods, the lead increases as the gear is brought into mid-position; but with crossed rods, the reverse is the case.

It can be shown that these statements are correct from an inspection of Fig. 52. The motion for both open and crossed rods is shown in mid-gear; the crank in each case is on the outer dead



point, and the port is open for lead. Suppose the link BC moved so that the point B is brought to the centre line DG . The point B is constrained to move in an arc whose centre is E , and therefore the shifting of the link motion must pull the valve to the left, because E is fixed. This movement manifestly lessens the port opening and decreases the lead. Applying the same reasoning to the crossed rod gear, it is seen that the valve spindle moves to the right as the block in the link approaches full gear. Generally, the longer the eccentric rods and the shorter the valve travel, the less will be the variation of lead. The truth of these statements is at once verified by a glance at the figure.

Macfarlane Gray's Method of Describing the Characteristic Line. — Macfarlane Gray has suggested a very

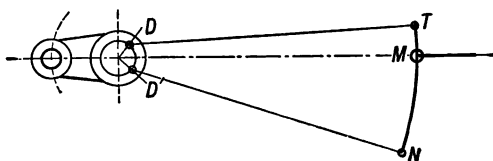
simple method of describing the line $E F$, which is as near the truth as practice demands. Describe with centre on $A J$ produced (Fig. 53) an arc passing through E and F with radius found as follows :—

Radius = length of eccentric-rod from centre to centre \times half the distance between the two eccentric sheaves \div the distance between the centres of the eccentric-rod pins on the link. Referred to Fig. 55, Radius = $\frac{D T \times D D'}{2 T N}$.

For open rods the arc is concave to the shaft; for crossed rods concave to the link.

It is instructive to apply the two methods given above, to one case of link motion, and observe the closeness of their agreement.

Fig. 55.



Link Motion "notched up."

The above constructions emphasize the advantage of keeping the eccentric throws short, the eccentric-rods long, and the link short, in order that the lead disturbance shall be a minimum. The first and third conditions are to be met by employing double-ported valves; and to keep the eccentric-rods long, the link should be located as near the valve chest as circumstances permit.

At this point it may be well to explain that the diagrams just given are approximate only. When valves are operated directly from eccentrics, the movement can be predetermined with great exactitude, but with link motions it is not so. So many points step in to modify the valve movement, that to pre-arrange a link motion that shall satisfy all conditions is impossible. The best that can be done is to secure the best action for full forward and full backward gear, and then, with the link properly suspended, the eccentric-rods long, and the valve travel short in proportion, the action for intermediate gear will be almost exactly that shown by the characteristic line in the diagram, and will be found satisfactory.

The foregoing constructions are, as said, only approximate, but there is a method whereby the valve movement can be determined exactly when the leading dimensions have been settled upon.

Let the accompanying diagram (Fig. 55a) represent, in outline, a link motion in which it is desired to determine the exact movement of the link. Let $A E$ and $A F$ be the backward and forward eccentrics respectively, $B C$ the link, and $D G$ the suspension link, shown in position for mid-gear. Divide the eccentric circle $E F$ into

eccentric as radius, describe an arc PQ ; and from F as centre, and with the length of the forward eccentric as radius, describe an arc RS . Now, it will be apparent that when the eccentrics are at A and A' , the centre of one pin hole of the link must be somewhere on PQ , assuming that the link is of the double bar form, shortly to be described; and the centre of the other pin hole must be somewhere on RS ; whilst the third point is somewhere on the arc JK , the path of the end of the suspension link.

Now prepare a tracing paper templet of the link, drawn to scale, marking thereon the position of the pin holes and the point of suspension. In the figure, such a templet is shown, X being the backward pin hole, Z the forward pin hole, and Y the suspension point. Applying this templet to the arcs PQ , RS , and JK , so that X is on PQ , Y on JK , and Z on RS , a definite position of the link is given, which can be pricked through to the paper below, and numbered to correspond with the eccentric circle. By repeating this process for all the other positions of the eccentrics, the point-path of the pin holes is tracked out, discovering the exact movements of these points. Taking the case of the present gear, the extreme horizontal points of the point D are seen to be D and H ; and since the valve spindle is in the direction AD , its travel will be exactly equal to DH ; and, further, since the link is in mid-gear, DH is equal to twice the lap *plus* twice the lead, so that either of these being known, the other is found. The peculiar paths of the pin holes are known as "slip curves," and indicate the amount of slotting motion of the die in the link.

The above method of tracing the valve motion is open to one objection, namely, that if the point-paths are to be drawn full size, the drawing must be as large as the whole gear itself, a condition which is usually inconvenient; but, by the method about to be described, the point-paths may be found without drawing the eccentric-rods in position.

In the figure, suppose the eccentric circle EF transposed to the left a distance $AT = EB = FC$; and let a templet LMN be prepared, having the radius O equal to AT , and the side MN in the direction of the radius. If this templet be applied to the transposed circle, so that the point M coincides with the chosen point in the circle, and the side MN is parallel to AD , the curved side LM contains the centre of the eccentric pin hole. The templet LMN being made of cardboard, or some other suitable material, the curve can be at once drawn on the paper. Similarly, placing the templet in position for the other eccentric, the curved side contains the centre of the other pin hole. Now, applying the link templet as before, so that each centre falls on the curves thus found, the link's position is discovered.* Referring to the figure,

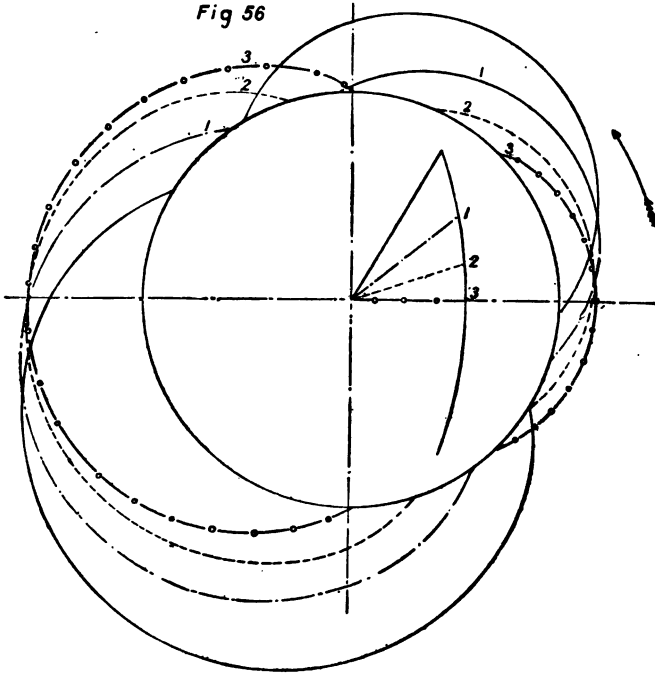
* A valuable paper on "Point-Paths in Mechanisms, found by the use of the templet," appeared in *Engineering*, vol. lvii., p. 439. The use of a templet in this way is applicable to many forms of link-work, and is especially valuable when the mechanism is too large to admit of all parts being drawn in position.

the positions of the templet for backward and forward eccentrics, when the latter are at 7, 7, are shown by dotted lines.

The exact valve movement being thus determined, the results may be referred to an ellipse diagram, or, still better, to a crank pin diagram about to be described. The inequalities for backward and forward running, and for full and middle gear are then clearly shown.

Crank Pin Diagram.—In order to show the steam action for various positions of the link block it is convenient to construct a crank pin diagram giving the opening to steam, the point of

Fig 56



admission, and other events in the stroke referred to a circle representing the path of the crank pin. In the accompanying figure, the curves 1, 2, 3 give the steam distribution corresponding to the valve circles 1, 2, 3 of Fig. 54. From these curves it is clearly seen that as the gear is moved towards the central position, the admission is earlier, the port opening less, and the cut-off earlier. The case in point is one in which inside lap, either positive or negative, is absent. The construction of this diagram, although tedious, is a very simple matter. The Zeuner diagram being drawn, the port opening for any crank position is known, and if various points through the stroke be taken, and the port

openings for each of these positions marked from the crank-pin circle (not necessarily drawn to scale), curves are obtained similar to those shown in the figure. The crank-pin diagram illustrates the action, perhaps, clearer than any other; and it has been the practice of some engineers to have such a diagram plotted down for each gear made, and carefully preserved with the drawings of the engine. The peculiarities of the gear

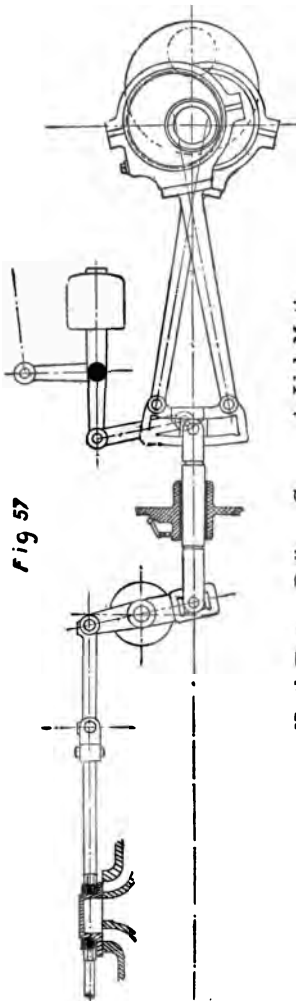
are thus graphically depicted; and should occasion arise to modify the valve motion, there is a true record of the existing conditions, and alterations can be made with confidence, knowing the exact state of matters with respect to the steam distribution.

Best Arrangement of Gear.—

In the shifting link motion, the point of suspension C, Fig. 51, may be at one extremity of the link as shown, or at a point midway between the eccentric-rod pin holes. The link for the former mode of suspension is of simpler construction than in the latter case. The suspension point, however, is often decided by the disposition of the adjacent parts of the engine. The central position, generally speaking, gives the easiest motion; but in many cases, notably in locomotives, suspension at this point would mean a very short lifting link, which is an objection. Another point requiring attention is that the arm of the lever G J is parallel to the valve spindle when the link is in mid-gear; and further, when the valve is central on the ports, the perpendicular from the suspension should bisect the versed sine of the arc described by the point G. In the figure these conditions have been fulfilled. Although not of vital importance, the arrangement just described is the best, and wherever possible should be adopted.

If any link gear be plotted down for various positions throughout the

stroke, the centres of the pin holes in the link will be found to describe peculiar curves, which resemble the figure of an attenuated



North-Eastern Railway Company's Link Motion.

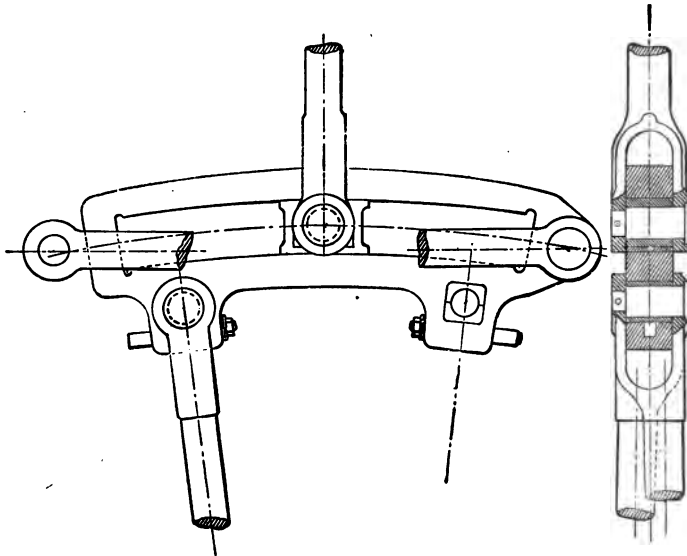
Fig 57

eight. These are known as "slip curves," and by their breadth denote the slip of the block in the link. The aim of the designer should be to reduce this slip as much as possible, so that the wear of the link is a minimum.

Link Motion made by the North-Eastern Railway Company.—Fig. 57 shows the form of link motion employed by the North-Eastern Railway Company on their express passenger locomotives. The valve chest is on the top of the cylinder, and the valve spindle derives its motion from the rocking lever in the manner shown. The object of presenting this illustration is to show the effect of the rocking lever on the setting of the eccentrics. In ordinary cases the eccentrics would be set in advance of the crank; but here they follow it, and have a position directly opposite the true setting for a link motion of the ordinary type.

The Slot Link.—The ordinary form of slot link is illustrated in Fig. 58.* The point of suspension is on the side remote from the

Fig. 58



The Slot Link.

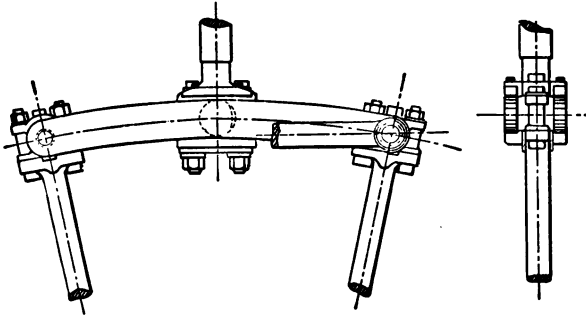
weigh-shaft. This form of link is very simple, and is much used for small engines. Its chief drawback is that no adjustment of the link block is possible; consequently any wear thereof causes considerable jar on the gear.

The Double-Bar Link with Eccentric-Rods Inside.—The next form is the double-bar link with eccentric-rods inside.

* The three drawings of links shown are taken from Seaton's *Manual of Marine Engineering*: Charles Griffin & Co., Limited.

The defect of the common slot link is avoided, but this advantage scarcely compensates for the defect introduced. The link cannot

Fig. 59.

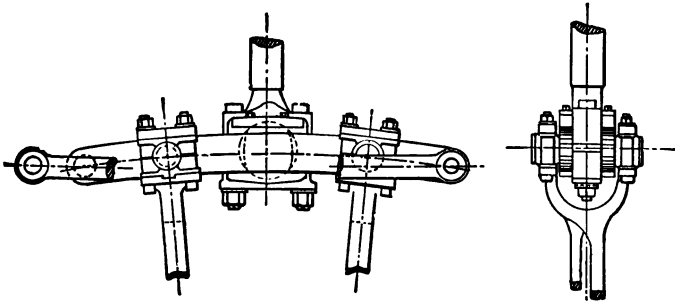


Double-Bar Link with Rods Inside.

be moved so that the end of the valve spindle is opposite the eccentric pin holes, and therefore the throw of the eccentrics must be greater than half the valve travel when set full gear. This is a disadvantage, since it incurs larger eccentrics, and, as a consequence, increased friction. The link itself is also considerably lengthened.

The Double-Bar Link with Eccentric-Rods Outside.—The double-bar link with rods outside is the best form, but the most expensive. The eccentric-rods are here forked, and embrace

Fig. 60.



Double-Bar Link with Rods Outside.

the link, thus allowing either eccentric pin hole to be brought opposite the valve spindle. The suspension point is at one extremity of the link, but, if desirable, could easily be in the centre. The above form is largely adopted in the Navy and Mercantile Marine.

Seaton, in his *Manual of Marine Engineering*, has given rules for proportioning the various details of link motion, which are of great practical value (Chapter xiii.).

Proportions of Links.—For the slot link, let D be the diameter of the valve spindle; then

| | |
|---|---------------------|
| Diameter of block-pin when overhung | = D . |
| Diameter of block-pin when secured at both ends | = $0.75D$. |
| Diameter of eccentric-rod pins | = $0.7D$. |
| Diameter of suspension-rod pins | = $0.55D$. |
| Diameter of suspension-rod pin when overhung | = $0.75D$. |
| Breadth of link | = 0.8 to $0.9D$. |
| Length of block | = 1.6 to $1.8D$. |
| Thickness of bars of link at middle | = $0.7D$. |
| If a single suspension-rod of round section, its diameter | = $0.7D$. |
| If two suspension-rods of round section, their diameter | = $0.55D$. |

Distance from centre to centre of eccentric-rod pin holes not less than two and a-half times the travel of the valve when in full gear, and when space permits, two and three-quarters to three times.

The unit D is obtained from the expression

$$D = \sqrt{\frac{L \times B \times p}{F}};$$

Where L = length of valve in inches.

B = breadth of valve in inches.

p = maximum absolute pressure to which valve is exposed, in pounds per square inch.

F = a factor having the following values under various circumstances:—

When the spindle is long and of iron $F = 10,000$.

When the spindle is long and of steel $F = 12,000$.

When the spindle is short and of iron $F = 12,000$.

When the spindle is short and of steel $F = 14,500$.

For the double-bar link with rods inside let D = diameter of valve spindle, as before.

| | |
|-------------------------------------|-------------------------------|
| Depth of bars | = $1.25D + \frac{1}{2}$ inch. |
| Thickness of bars | = $0.5D + \frac{1}{4}$ inch. |
| Length of sliding block | = 2.5 to $3D$. |
| Diameter of eccentric-rod pins | = $0.8D + \frac{1}{4}$ inch. |
| Diameter of centre of sliding block | = $1.3D$. |

Distance from centre to centre of eccentric-rod pin holes three to four times full travel of eccentric-rods.

In the double-bar link with rods outside, D = diameter of valve spindle.

| | |
|--------------------------------|-------------------------------|
| Depth of bars | = $1.25D + \frac{1}{2}$ inch. |
| Thickness of bars | = $0.5D + \frac{1}{4}$ inch. |
| Length of sliding block | = 2.5 to $3D$. |
| Diameter of eccentric-rod pins | = $0.75D$. |

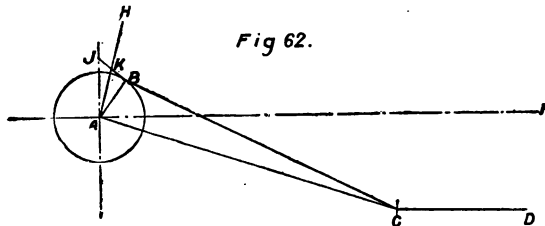
Distance between eccentric-rod pin holes two and a-half to two and three quarter times the full travel of the valve.

Gooch's Link Motion.—The stationary-link gear, introduced by Sir Daniel Gooch, consists of two eccentrics AE and AF coupled to the link BC by eccentric-rods EB and FC . The link is curved towards the cylinder with a radius equal to the length of

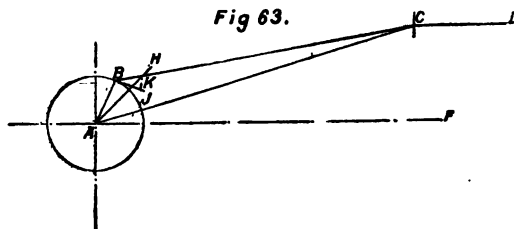
compensated in some degree by the improved valve movement, whereby the lead is constant for all positions of the radius-rod. That such is the case will be apparent from an inspection of the figure. The crank $A L$ is supposed to be on the outer dead centre, and when in this position, the valve, if correctly set, gives the desired amount of lead. Now, since the link has a radius equal to the length of the radius-rod, and because the eccentric-rods being of equal length, the link is vertical, it follows that $B D$ can be swept through the whole length of the link without altering the position of D ; and since the valve spindle is stationary, the lead is unaltered.

It remains to find the characteristic line of the gear; and, having obtained this, to determine the action for full forward or full backward gear, or for any intermediate position.

Eccentrics Driving Obliquely.—Before entering on this matter it is necessary to investigate the action of an eccentric



driving a valve spindle in an oblique direction. Let $A B$ (Fig. 62) be an eccentric, and BC an eccentric-rod driving a valve-rod CD in a horizontal direction. Draw the straight line AC connecting the centre line of the crank shaft and the end of the eccentric-rod. This line makes an angle CAF with the horizontal line AF . Draw the line AH , making angle BAH equal to angle CAF . At right angles to BA draw BJ , intersecting the line AH at K . Then AK is the throw and position of an eccentric, which, driving the valve spindle directly, would give approximately the same steam distribution as an eccentric AB driving the valve spindle obliquely. The foregoing construction, although not admitting of



exact mathematical proof, is so very near absolute truth as to be quite satisfactory for all practical purposes.

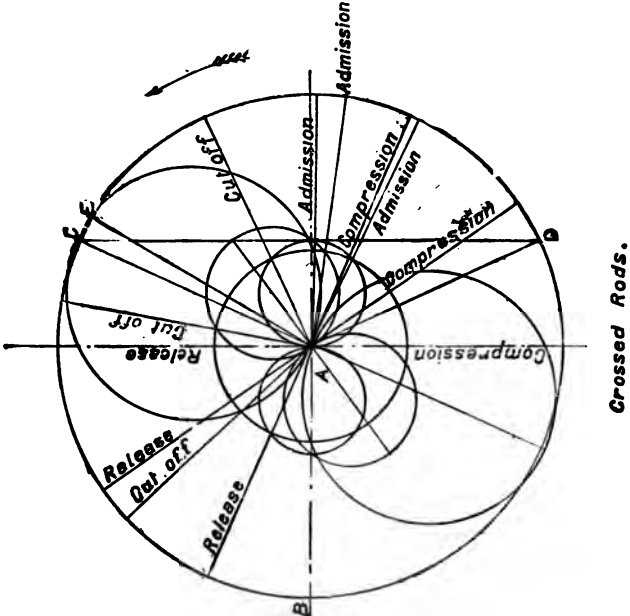
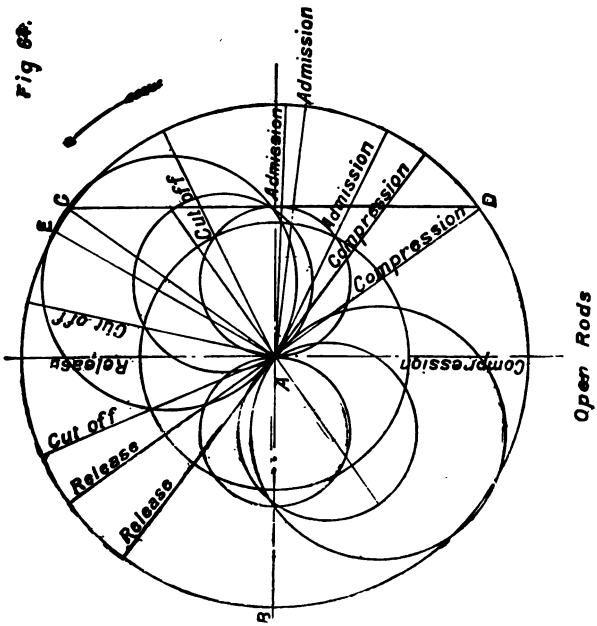
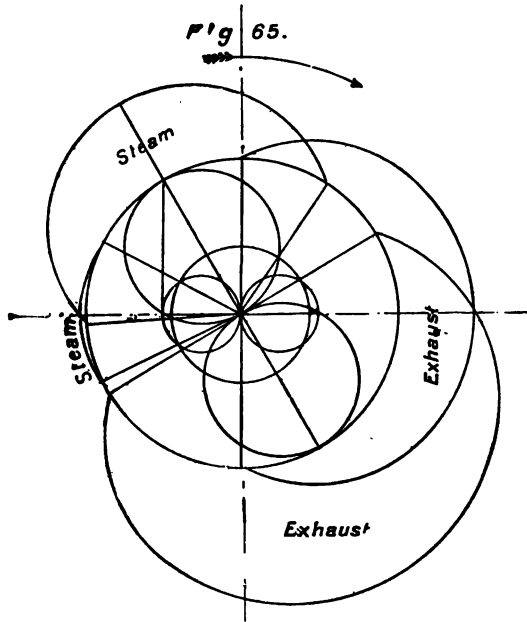


Fig 60.



In Fig. 63 consider the eccentric AB driving the valve spindle in the manner shown. Join AC , and make angle BAH equal to angle CAF . Draw BJ perpendicular to BA , cutting the line AH at K . Then AK is the throw and position of an imaginary eccentric, which, driving the valve-rod directly, would give approximately the same action as AB driving it in an oblique manner.

Valve Diagram for Gooch's Link Motion.—In Fig. 64 let AE represent the throw and position of one of the eccentrics in a stationary link motion, in relation to the real position of the crank AB . Make AC equal to the throw and position of the virtual



eccentric arm, obtained in the manner just explained. Draw the vertical CD , which is the characteristic line of the gear, and contains the extremities of the virtual eccentric arms for all positions. By dividing the line CD in the same proportion that the block divides the link, the equivalent eccentric for that position is obtained, and the valve action for that particular position can be shown by Zeuner circles. In the figure several positions have been taken, and the points of admission, cut-off, &c., clearly indicated.

Crank-Pin Diagram.—In figure 65 a crank-pin diagram has been constructed, for full and mid gear, showing, as the characteristic line indicates, a constant lead for both grades of cut-off.

Best Arrangement of Gear.—The stationary link is more sensitive to the point of suspension than the shifting link, and unless there are strong reasons for not doing so, the point of suspension should be placed in the arc of the centre line of the link, and midway between the eccentric pin holes. The correct horizontal position of K is somewhere on a vertical line which bisects the arc described by the central point of the link, J—an arc whose length is equal to twice the lap *plus* twice the lead. Finally, the link J K should be as long as convenient. The above conditions have been carried out in the design shown by Fig. 61. It is difficult to explain why these positions are the best; but plotting down the slip curves for various points of suspension will clearly show that they are.

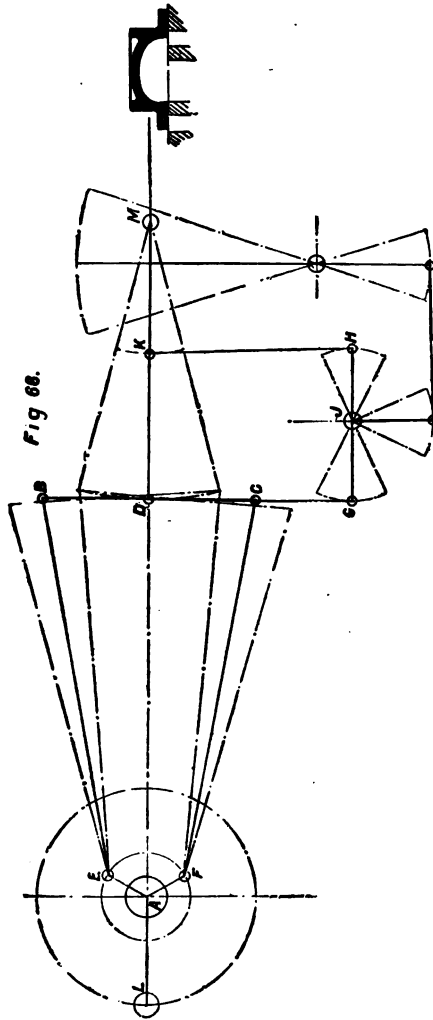
As to the point G (Fig. 61), it may be anywhere on the radius rod, and is often placed half way between the extremities. The intermediate link-work between G and the reversing handle M N is necessarily one of convenience, the aim being to move the block of the radius-rod its full extent by a suitable movement of the handle on the reversing lever. To arrange for a movement of from 2 feet 3 inches to 2 feet 9 inches is a common allowance. When reversal is effected by a hand wheel and screw thread, as is common in locomotives and marine work, the mechanical advantage between the wheel and the lifting link is not restricted in any way. To balance the weight of the radius-rod and lifting link, the lever H M is made double ended, and carries a balance weight on the arm M O.

The proportions of the Stephenson link given on a previous page apply equally to the Gooch link gear, and can be relied upon giving good results.

Allan's Straight Link Motion.—The Allan straight link motion is obviously a combination of the shifting and stationary link gears. In the present arrangement the link and radius-rod are moved in opposite directions. The eccentric-rods may be open or crossed. With open rods the lead of the valve increases as the link is brought into mid-gear; but with crossed rods the reverse is the case. It will be shown, however, that this variation is somewhat less than in the shifting link with the same length of rods; but as the Allan gear occupies more length than the former, the eccentric-rods are generally shorter; so that finally, the lead variation is little less than with the common form. The two extra joints introduced are an objection; and altogether it is difficult to see that the straight link gear is an improvement on its predecessors. This much, however, may be said; the movement of the link and radius-rod being in opposite directions, the vibration of these parts between extreme positions is less; and, therefore, in confined situations its use may be desirable. Another point in its favour is the straight link, which is somewhat easier to construct than a curved one.

In the skeleton diagram, Fig. 66, A E and A F are the eccentrics relative to the real position of the crank A L. B C is the straight

link connected to the eccentric-rods. The link is supported from a point central between the two pin holes, by the lifting link D G. This rod in turn is centred upon one end of a double-armed lever

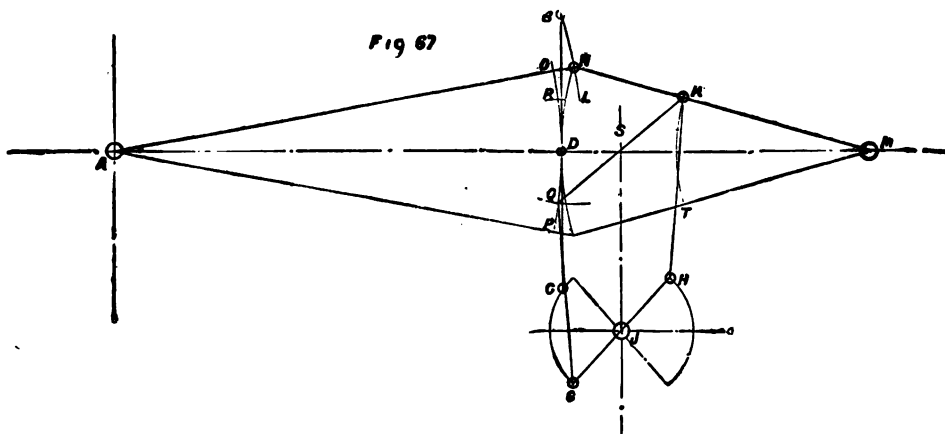


CH having J for a fulcrum. HK is the radius-rod lifting link moving BM in an opposite direction to BO.

In raising the link from mid position to full gear the movement is less than would be the case for the shifting link as said, and the

inequality of lead is approximately that which would result by moving the link of a Stephenson gear, having the same length of eccentric-rods, in amount equal to the distance moved by the Allan link. In the shifting link, it has already been shown that the lead variation increases as the movement of the link, so that the reason of the variation being less with Allan gear will be understood.

Diagram for Allan's Gear.—The location of the centre of the weigh-shaft *J* is an important matter. In the following diagram, Fig. 67, *A* is the centre of the crank shaft, and *BC* is the link. From *A* as centre, and with *AB* as radius, describe the arc *BL*; and from *M* as centre, and with *MD* as radius, draw the arc *DN* intersecting *BL* in *N*. Join *AN* and *MN*. The point *N* indicates the position of the ends of the eccentric- and radius-rods when in



full gear. Fix upon the suspension point *K*, in the radius-rod; and from *M* as centre and with radius *KM* describe the arc. From *A* as centre, and with radius *AD*, describe arc *OP*. With centre *N*, and radius equal to half the distance between the pin holes in link (*DB = DC*, in the figure), cut the arc *OP* in *Q*. Join *K* and *Q*. The line *KQ* crosses the centre line *AM* at *S*; and a vertical from *S* contains the proper centre of the weigh-shaft. Let the vertical position of the shaft be fixed upon, and lettered *J*. Then the double-armed lever *GH* should be designed so that the bisection of the versed sines of the arcs described by the extremities of *GH* are vertical with the bisection of the versed sines of arcs *QR* and *KT*.

The above construction is not imperative, but it is the one that gives the easiest running. Sometimes the point of suspension of the radius-rod is on the opposite side of the link to that shown above, the radius-rod extending past the link *BC* to accommodate the lifting levers; and sometimes the link is slung from above, the

point of suspension being at the lower end of the link. This is the arrangement adopted by Mr. David Jones on the Highland Railway goods engines.

Expansion Gears and Link Motions Combined.—When expansion gear is employed in conjunction with link motion, the position of the expansion eccentric must be directly opposite the crank, if similar action for forward and backward running is desired.

CHAPTER IV.

OTHER REVERSING GEARS.

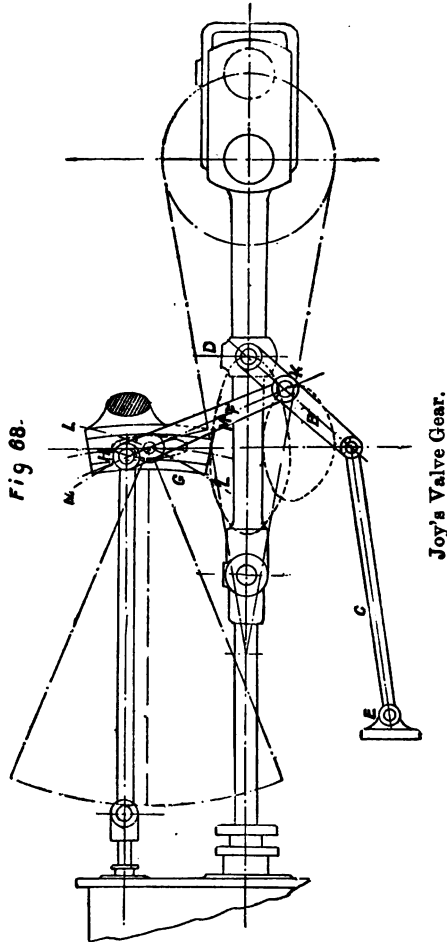
CONTENTS.—Principle of Radial Gears—Joy's Valve Gear—Diagram for setting out Joy's Valve Gear—Joy's Gear on Marine Engine—Hackworth's Valve Gear—Objection to Hackworth's Gear—Bremme's Valve Gear—Practical Example of Bremme's Gear—Comparison of Joy's and Bremme's Gear.

THE defects of ordinary link gears have caused engineers to seek for other means of reversing, which shall be free from the objections to reversing gears of the link type, and which, at the same time, shall be quite as simple and effective. This effort has evolved several well-known forms of link-work for actuating the valve, to which the name Radial Valve Gear is given.

Principle of Radial Gears.—The general principle of radial gears is that of obtaining from some reciprocating or revolving piece of the engine, an arrangement of link-work, a point in which shall describe an oval curve, and by altering the direction of the axes of this curve, to produce reversal, variable expansion, or stoppage.

Joy's Valve Gear.—Of radial gears, the Joy valve motion is perhaps the best known. At a suitable point D in the connecting-rod (Fig. 68), the link B is connected, its lower extremity being guided by an anchor link C, which has E for a fulcrum; E being carried from a suitable part of the engine frame. The link F is guided in a curved slot G, which, together with the movement derived from B, constrains the point H to move in an oval curve. The valve-rod J is connected to the extremity H, and imparts motion to the valve. Plotting down the paths of D, K, and H will discover that these points move in paths similar to the dotted curves shown in the figure. Now the crank being on the outer dead centre, as shown, and the curved slot G being vertical, it will be understood that if the total breadth of the curve described by H be equal to twice the lap *plus* twice the lead, the valve will simply move to and fro on the port face, opening each port alternately by the amount of lead. This will be the action for mid-gear. Now, suppose the angle of the curved slot altered to LL. The path described by H will still be of the same form, but altered in position; and because of this altered position will impart an increased travel to the valve. Again, suppose the slot moved the

same angle on the other side of its vertical position. The valve now has the same travel as before; but, because of the altered angle of the guide, the valve's motion will commence in the opposite direction, thus reversing the engine. It will also be understood that, by giving any intermediate position to the slot between the



central point and L L, the valve travel is proportionally increased or decreased, as the case may be, thus varying the point of cut-off; and that any intermediate position between the central line and M M will also produce a variation of cut-off; but the motion will be in the reverse direction to that caused by having the slot inclined on the other side of the vertical.

The correct method of laying down the various centres of the Joy gear is set forth in a pamphlet issued by Mr. David Joy, the inventor. The method is as follows:—

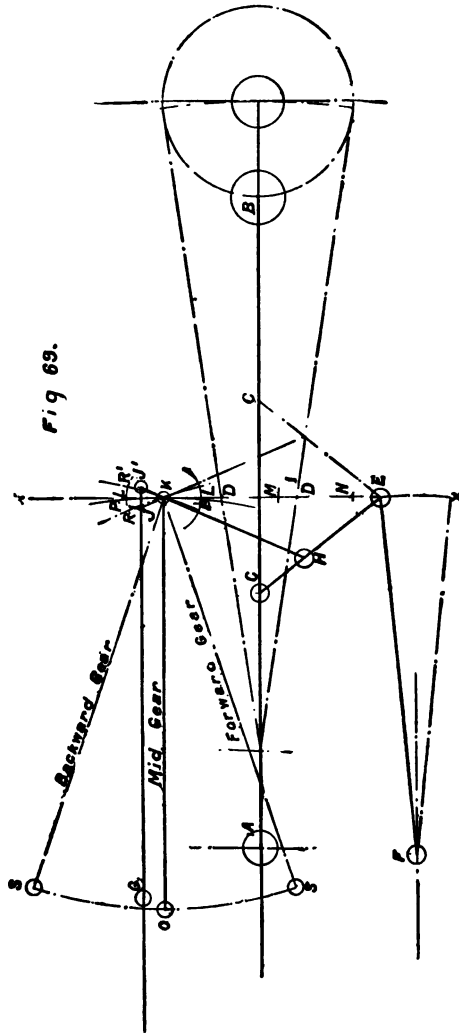
Diagram for Setting out Joy's Valve Gear.—On the connecting-rod AB , take a point C , so that its total vertical vibration DD^1 is not less than twice the full valve travel, preferably a little more.* Through DD^1 draw XX perpendicular to the horizontal AB ; and at the proper distance from AB lay down the centre line of the valve spindle. Mark the extreme position of the point C for inner and outer dead centres; and choose such a lever CE whose total angle of vibration CEC^1 does not exceed 90° ; and carry the end E by an anchor link EF , the mid position of which is parallel to the connecting-rod when horizontal.

Next, on the centre line of the valve spindle produced, and on each side of the vertical XX , mark off the points JJ' each distant from the vertical by an amount equal to lap and lead. From the point J draw a line JH , the centre line of a link that, by virtue of its connection to CE , will move the point K —the point where JH crosses the vertical—equally on each side of the central point K . The point K is the centre of oscillation of the curved guides in which slide the blocks carrying the fulcrum M of the lever JH . The position of H is best found by a tentative process; and to test whether the chosen point be a correct one, the equal vibration required is marked off on each side of K , and lettered LL . The distance LL is equal to the vertical vibration of the point c on the connecting-rod, that is, DD' . From D as centre, and with CH as radius, mark the point M in the vertical XX ; and with the same radius mark off N from D' . M and N are the positions of H when the engine is at half stroke, or thereabouts, and these points give the total vertical vibration of H . From M as centre, and with HK as radius, describe an arc cutting the vertical XX ; and from N as centre, and with the same radius describe an arc also cutting the vertical XX . Then, if the point H be the correct one, the arcs just drawn cut the vertical XX at L and L . Should the points of intersection fall *below* L and L , the point H is too near E ; but if they fall *above* L and L , H is too near C . The exact position of H is generally found on a second trial.

The valve-rod JG may be of any convenient length, but the centre line of the slides must be struck with the same radius. From the point K draw a line KO parallel to AB ; and with centre on this line, and with JG as radius, describe an arc containing K , and cutting the curves LL , struck from K as centre, in PP' . From P or P' , and on each side thereof, mark off on the arcs LL an amount equal to one and a quarter times the maximum port opening required, and let RR' be the points. With centres on the arcs SS struck from centre K , describe arcs passing through KR and

* The port opening being determined, the desired point of cut-off, and the lead being known, it is possible to estimate the requisite travel by diagram 1 or 5, pp. 3 and 8.

K R'. These arcs represent the centre lines of the curved slots for forward and backward gear, and when the latter are in either of these positions the point of cut-off is about 75 per cent. Should a



later cut-off be desired, the slots must be carried still further from their vertical position.

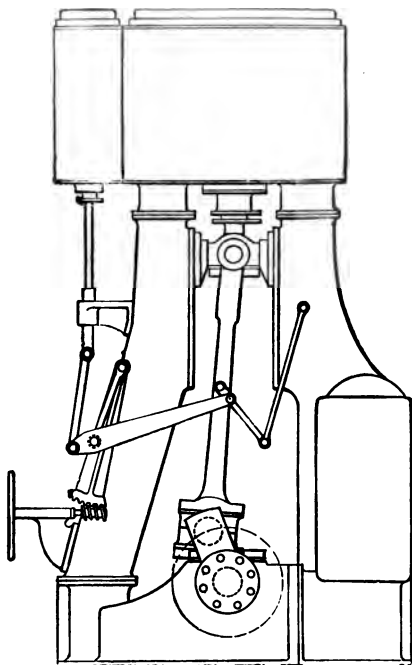
Glancing at the diagram, it will be seen that the fulcrum K of the lever JH coincides with the centre of oscillation of the curved

slots or guides when the crank is on either dead centre. It is evident that when these points coincide the angle of the guide can be altered to any extent without disturbing any other part of the mechanism, a state of things which shows that the lead is constant for all positions of the reversing handle.

The inventor's pamphlet goes on to say that when the above directions are followed, the leads and cut-offs for each end of the cylinder, for backward and forward gear, are practically equal.

The arrangement of the gear as just described is the most effective, but considerable latitude is permissible. For instance,

Fig. 70.



Joy's Valve Gear applied to Marine Engines.

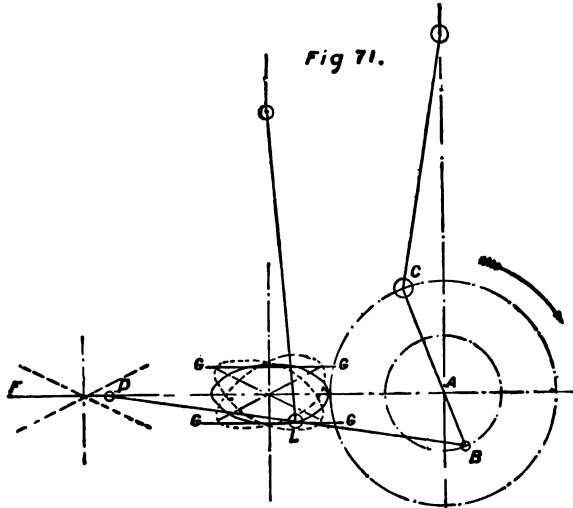
the point C can be placed above or below the centre line of the connecting-rod, and the point K can be raised or lowered, so that the line KO is no longer parallel to AB; but it is not advisable that the line should have a greater inclination to AB than 4° , or thereabouts. Again, the anchor link may be dispensed with, the point J being guided in a slide affixed to some convenient part of the engine.

For vertical engines the same rules apply by placing the diagram vertically, and altering relatively the terms "vertical" and "horizontal."

The valve motion arising from the link-work of this gear is superior to the ordinary eccentric motion. If the movement of the parts be traced round for a complete revolution of the crank, it will be found that when opening and closing the steam ports the valve travels rapidly; but during expansion and exhaust the movement is slow. Another advantage, in the case of locomotives, is the space saved on the crank shaft, due to the absence of eccentrics, whereby longer journals and crank pins are obtainable.

Joy's Gear on Marine Engine.—As an example of the gear applied to a marine engine, the annexed figure (70) from *Seaton's Manual* is presented. The reversing wheel actuating the worm gearing with the toothed sector is clearly shown. The curved guide is here dispensed with, the end of the reversing sector carrying a lever which has the same function.

Hackworth's Valve Gear.—Hackworth's Valve Gear, shown diagrammatically in Fig. 71, consists of an eccentric A B placed



Hackworth's Valve Gear.

directly opposite the crank A C, actuating the eccentric-rod B D, the extremity of which is constrained to move in a straight guide F, the angle of which can be varied similarly to the guide of the Joy gear. A point L in the eccentric-rod is employed to give the valve movement. It will be seen that when the position of the guide is horizontal, the point L will describe an oval curve, whose major axes is parallel to F. When the direction of the guide is altered the axes of the curve vary correspondingly, and the motion imparted to the valve is increased. The gear is so set out that when the crank is on dead centre the point D coincides with the

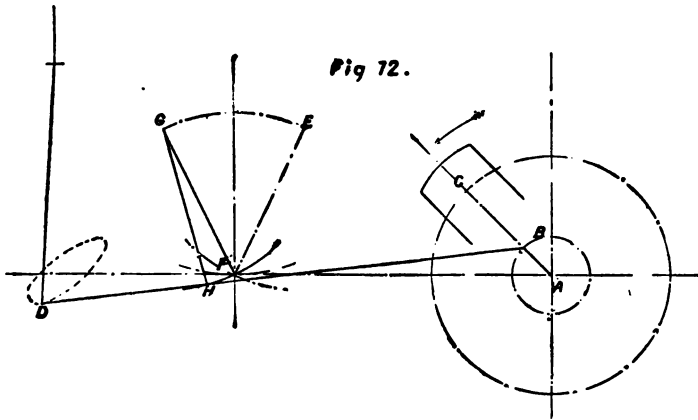
centre of oscillation of F. It is clear, therefore, that F can be pulled over in any direction without disturbing the lead.

The paths of L corresponding to the three positions of the guide F are shown. Let the horizontal G G be drawn on each side of the horizontal A B, and removed from it a distance equal to the outside lap. The port opening for each position will then be indicated; and from the figure it appears that when the slot is horizontal, the maximum port opening is only equal to the lead.

By tracing the gear round through a complete revolution it will be found that the valve acts most efficiently, having a rapid motion when opening and shutting, but during the closed periods the motion is somewhat slow.

Bremme's Valve Gear.—In the Bremme Gear an intermediate point of the eccentric-rod moves in a curved path instead of a straight line, and the point of attachment of the valve lever is at the extremity of the rod. Fig. 72 will render the action clear.

Diagram of Bremme's Gear.—The eccentric A B, whose position coincides with the crank A C, actuates the eccentric-rod



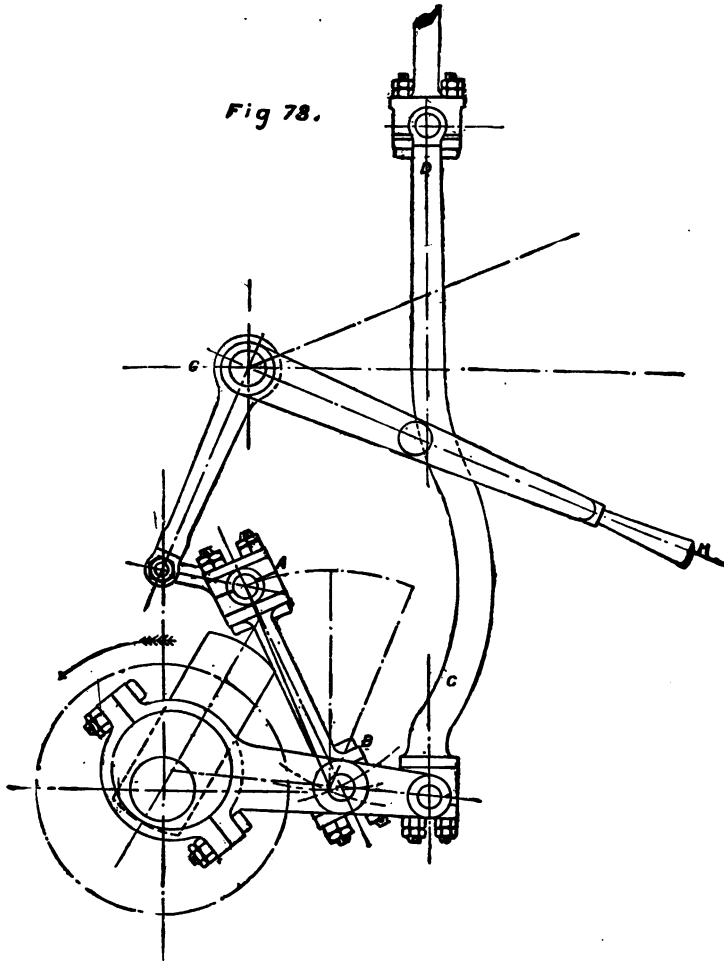
Bremme's Valve Gear.

B D, which, at a point H, is constrained to move in an arc having a radius equal to the suspension lever G H, and a centre at G. When the lever G H has the position shown, the crank revolves in the direction indicated. Now let the reversing lever G F, having a fulcrum at F, and the same length as G H, be pulled over to E. The point G of the lever G H now coincides with E, and the arc in which H is constrained to move has its centre at E. This changes the direction of the axis of the oval curve described by D, and consequently produces reversal of the engine.

As in the gears already described, the mechanism is so set out that the guided point of the eccentric-rod coincides with the centre

of oscillation of the reversing lever each time the crank is on the dead centre, thus producing equal leads. The angle of the reversing lever G F from the central line, and known as the "deviation" angle, should, the inventor states, never exceed 25° on either side.

The fact of the point H moving in an arc produces inequality in the valve's motion on each side of its central position, which causes cut-off and compression to fall earlier in the down than in the up stroke; but so far from this being an objection, it is an advantage, for the increased compression serves to neutralise the downward momentum of the piston-rod and connecting-rod.



Bremme's Valve Gear applied to Vertical Marine Engines.

Practical Example of Bremme's Gear.—Fig. 73 shows a form of the Bremme gear in its practical application to vertical marine engines. The reversing handle *GH* moves the reversing arm by means of a wiper rod and short drag link. The suspension-rod *AB* is slung from the extremity of the reversing arm, and carries the eccentric-rod at its lower end. In the figure the reversing arm has been purposely omitted in order to avoid confusion with the suspension-rod *AB*. The centre line of the former, however, is drawn, and also its extreme position on the other side of the vertical, the total angle of deviation in this instance being 40° . The valve-rod *CD* and the reversing handle are in front of the engine, the latter being locked in any position by an arrangement carried on one of the engine stanchions.

Comparison of Joy's and Bremme's Gear.—Comparing the merits of the Joy and Bremme gears, it would appear that for locomotives the Joy gear is to be preferred; but Bremme's gear is the best adapted for marine work. It would be somewhat difficult to arrange the Bremme gear with its eccentric-rod and reversing arm underneath the locomotive boiler, so as to be compact and clear the various parts. In marine work, however, the case is different. Here the space for the eccentric-rod and levers is usually abundant, and the reversing lever can be conveniently situated. The movement of the parts of the Bremme gear is considerably less than that of the parts of its rival, and this is a consideration in the engine room of a steamship where space is limited, and where it is necessary for the attendants to be in close proximity to the working parts.

The objection to radial gears, as a class, is the number of parts in continual wear. These parts, unless very substantial and adjustable, soon work loose, and cause rattle, besides disturbing the valve action. But given good design and first-class workmanship, there is no reason why radial gears should not wear as long as link motions, and the former have undoubtedly considerable advantages in the direction of improved steam distribution.

PART II.

CORLISS VALVES.

PART II.

CORLISS VALVES.

CHAPTER I.

GEARS WITHOUT TRIP MOTION.

CONTENTS.—Advantages of Corliss Gears—Classification of Corliss Gears—Valve Gear without Trip Motion—Effect of Wrist Plate—Reduction of Dwelling Angle—Location of Wrist-Plate Pin—Rules for Diameter of Valves—Angle of Vibration—Position of Levers—Valve Diagram for Corliss Gear—Proportions of Steam Valve and of Exhaust Valve—Double-Ported Valves—Equilibrium Corliss Valve—Crank-Shaft Governors applied to Corliss Valves—Diagrams of Valve Motion.

ABOUT the year 1850, G. H. Corliss constructed the form of valve which bears his name. Since that time the Corliss valve and its operating mechanism have been modified and improved, until they have attained their present state of perfection, and seem to have settled down to certain designs, which it appears difficult to better.

Advantages of Corliss Gears.—The Corliss valve may be briefly described as being of cylindrical form, working on a cylindrical face, and vibrating on its longitudinal axis. It is the outcome of an effort to produce a valve gear which would present the following advantages:—

1. Minimum of power to actuate the gear.
2. Smallness of clearance spaces.
3. Adaptability to close governing.
4. Good steam opening; instantaneous cut-off; and free exhaust.

Classification of Corliss Gears.—It will be convenient to classify Corliss gears under three heads:—

1. Gears without trip motion.
2. Single eccentric gears with trip motion.
3. Double eccentric gears with trip motion.

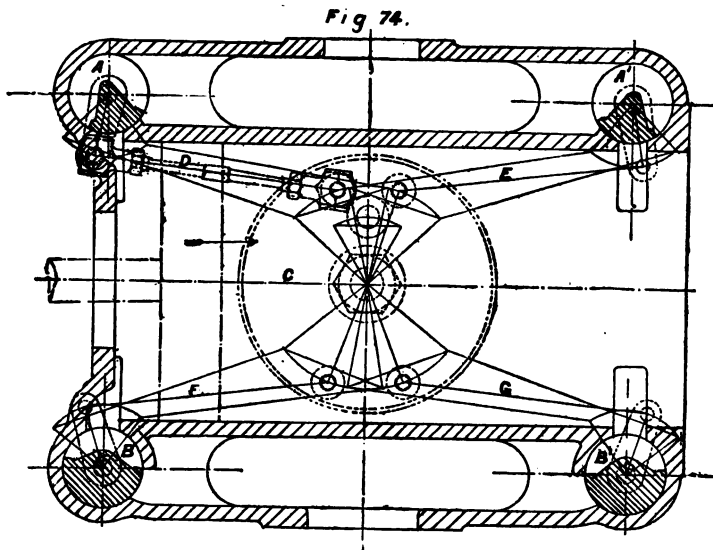
The first class is seldom used. The valves have a positive connection with the eccentric, the travel is constant, and the point of cut-off invariable.

In the second class, the steam valves have no positive connection with the eccentric, but are opened by catches against the resistance of a dashpot, and released at some point of the stroke determined by the governor, or otherwise. The exhaust valves are positively connected to the eccentric and receive a constant movement.

The double eccentric gear is the form usually made in this country. In this class the steam valves are operated in the same manner as in the single eccentric gears, but the exhaust valves are driven from a separate eccentric.

As the action of the first class embodies that of gears with trip motion, it will be conveniently discussed at the outset.

Valve Gear without Trip Motion.—Fig. 74 shows an arrangement of Corliss motion without trip gear. AA' are the

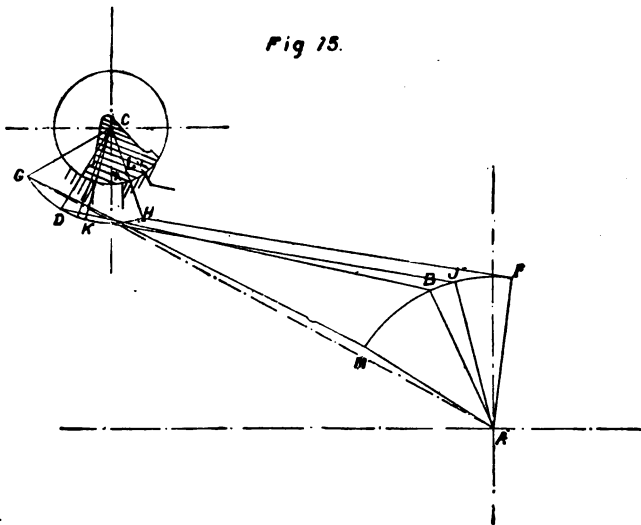


Corliss Motion without Trip Gear.

steam, and BB' the exhaust valves. These valves are actuated by the eccentric through the medium of the wrist plate C and the wrist plate rods $DEFG$. When the piston is at the beginning of the stroke and about to travel in the direction of the arrow, the valve will be open a certain amount. This will be lead. At the same time B' will be open for exhaust, and the valves A' and B will be closed. The figure shows the wrist plate in its central position, at which time all the ports are closed as indicated. It will be remembered that when a slide valve is in its central position both steam and exhaust ports are closed, assuming that there is no inside clearance; and the probable position of the piston would then be about 10 per cent. from the end of the stroke. The same

condition of things occurs in Corliss gear when the piston is at the same point of its stroke, a position indicated by the dotted lines in the figure. Now it will be easily seen that the front steam valve A has the same function as the front steam edge of an ordinary valve, the back steam valve corresponds to the back steam edge of the slide valve; whilst the front and back exhaust valves produce the same distribution as the front and back exhaust edges of the slide valve. Bearing this in mind the action of the four valves is at once understood.

Effect of Wrist Plate.—The presence of the wrist plate modifies the motion of the valves due to the eccentric to a considerable extent; and the location of the valve-rod pin on the wrist-plate pin is one of the important points in Corliss work. In Fig. 75 is shown



Steam Valve Lever and Wrist-Plate Rod in three positions.

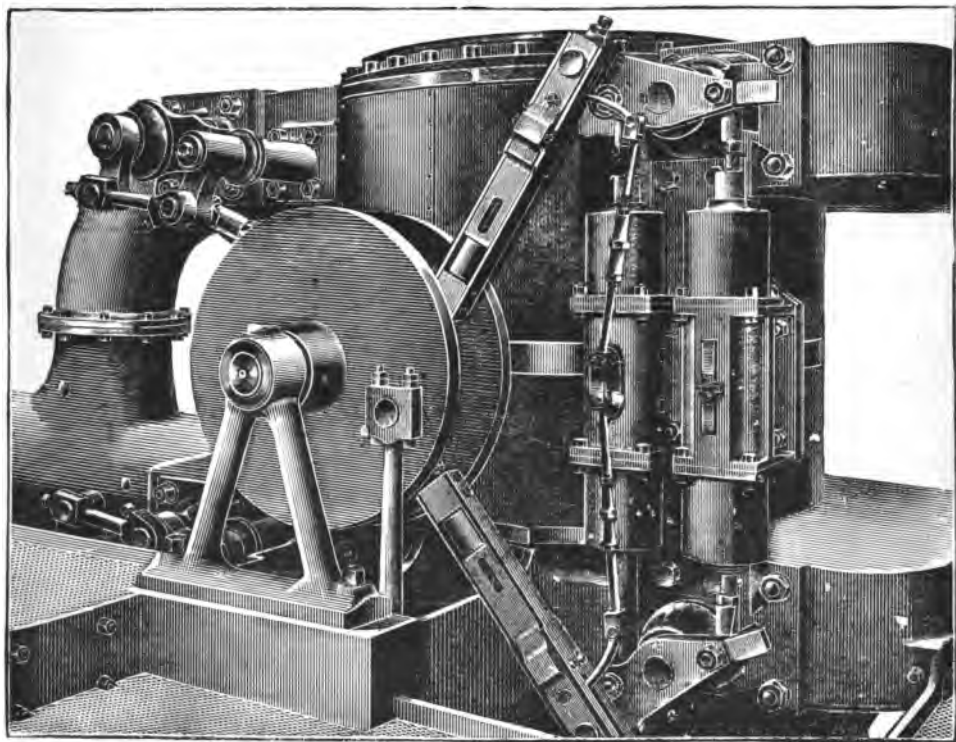
the centre lines of the steam valve lever and wrist-plate rod in three positions. The wrist plate, by virtue of its connection with the eccentric-rod, oscillates through an angle of 33° on each side of its central position, denoted by the line AB; but, by the particular location of the wrist-plate pin B, the valve lever CD swings through an angle of 28° on one side of the position CD, and 51° on the other.

The advantage of this translation of the eccentric's motion will be explained. When the wrist-plate lever is at G, the valve covers the port by an amount equal to the lap *plus* the angle DCG taken at the valve circumference. Now, so long as the valve opens to steam at the proper instant, it matters not what its motion between G and D may be, because all that motion, so far as this particular

valve is concerned, is useless. This movement is known as the "dwelling" motion; for during the time it is being worked through, the valve is merely idling over the port. From what has been said, it is apparent that the less the dwelling angle the better; and one advantage of the wrist plate is this, that it permits of the dwelling angle being kept small. If there were no wrist plate—the eccentric-rod coupling directly to the valve lever *OD*—the dwelling angle would be half the total angle moved through by the valve.

Reduction of Dwelling Angle.—In very large engines, the advantage of a small dwelling angle becomes more pronounced, and,

Fig 76.



Low-Pressure Gear of Engine designed by Hick, Hargreaves & Co. (by permission of *Engineering, Ltd.*).

cognisant of this, Messrs. Hick, Hargreaves & Co., Bolton in one of their large vertical engines, have gone so far as to introduce an additional lever and rod to actuate the exhaust valves; and by

this means to reduce the dwelling angle to a considerable extent. The accompanying illustration (Fig. 76) is a perspective view of the low-pressure gear of the engine referred to; from which a good idea of the motion may be gathered. On the exhaust side (the left-hand side of the figure) is seen the idling lever and its connection with the wrist plate. Without at present attempting to describe the steam portion of the figure, it may be stated that the trip motion is the well-known Inglis and Spencer gear; and that the large size of the valves necessitated the use of double dashpots; an arrangement whose advantages will be appreciated when trip gears have been discussed.

Another advantage which the wrist plate possesses is the quick steam opening that can be obtained by a suitable location of B (Fig. 75). In Fig. 75, the lap of the valve is indicated, and also the position of the valve lever when the port is open for lead. The corresponding position of the wrist-plate pin is J. The angle J A F is 22° , and the angle K C H, 35° . From K to H is the opening angle of the valve, and it will be understood that the quicker this angle is worked through, the better the steam line on the indicator diagram. Angles J A F and K C H are both worked through in the same time, so that the port opening is quicker in the proportion of $\frac{3}{4} : 1$, than would be the case if there were no modification of the eccentric's motion. The rapid movement through the angle K O H throws little extra work on the wrist-plate pins and rods; for when the valve is moving through the dwelling angle, the whole of its surface is under the influence of unbalanced steam pressure; but when the port is open and an equal pressure is established in the cylinder and valve chamber, the only surface is the width of the facing on the back edge of the port. This distance is indicated by L in Fig. 75.

Location of Wrist-Plate Pin.—Whilst endeavouring to keep the dwelling angle small, it must not be forgotten that by placing the wrist-plate pins too near the horizontal centre line of the wrist plate, the motion will give a double stress on the wrist-plate and valve-lever pins. This should be avoided. In Fig. 75, the centre line of the wrist-plate rod in its extreme position is above the line passing through the extreme position of the valve-lever pin and the centre line of the wrist plate; thus showing that no double reversal of stress occurs. In all wrist-plate gears, the line A M should be the limit of the wrist-plate pin's movement on that side of its central position. The location of B is also governed by the end of the valve-rod, it being evident that the pins must be sufficiently wide of each other to clear the ends of the rods. Sometimes, however, one pin on the vertical centre line of the wrist plate has been used for both rods.

Rules for Diameter of Valves.—The diameter of valves for any given size of cylinder is the next point to consider. This size is usually determined from some empirical formula. It is customary

to let one size of valve serve for several sizes of cylinders, thus effecting a saving in templets and patterns. The rule

$$d = \frac{D}{8} + 2$$

expresses very closely the relation between the size of cylinder and valve. Here d and D are the diameters of the valve and cylinder respectively.

The exhaust valves are sometimes made larger than the steam valves. Then

$$\frac{D}{6} + 2$$

would give a result conformable with modern practice.* The length of the ports on the valve face is in nearly all cases made equal to the diameter of the cylinder, and, having the length decided upon, decides the width.

The length of the valve lever is usually proportioned from the diameter of the valve, although in some cases it is governed to a certain extent by the trip motion. A rule agreeing well with practice and allowing an increasing leverage for high pressures is as follows:—

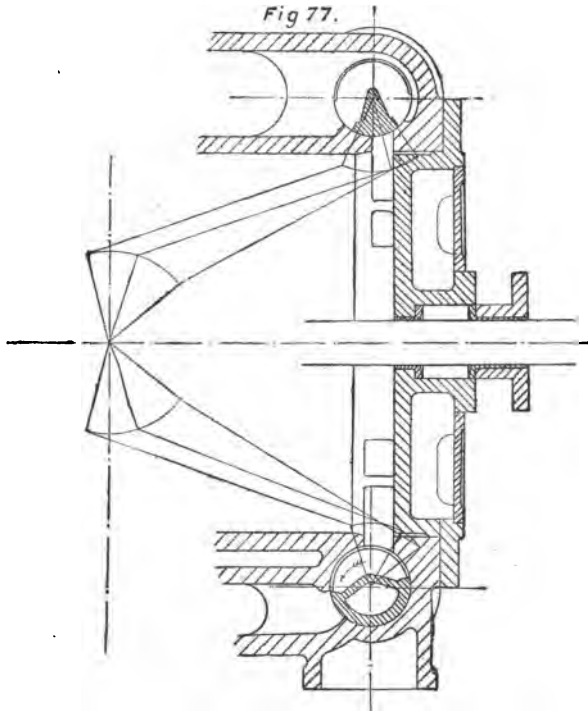
Length of lever = $1.7 \times$ radius of valve + $\frac{1}{4}$ inch for every 10 lbs. above 100 lbs. initial pressure.

Angle of Vibration.—The angle of movement of the valve levers is usually made from 60° to 70° . The dwelling angle *plus* the lap angle has to be worked through before any port opening is obtained, so that the remaining movement is left for port opening. If the wrist-plate diagram has been laid down, the movement of the valve on the face is at once seen; and when the lap angle has been indicated, the amount of travel left for port opening is shown. It is advisable that this should slightly exceed the width of the port in order that a full port opening may be obtained early in the stroke. Should the angle shown not be great enough to give the over travel, a little alteration in the position of the wrist plate pins would perhaps effect all that is required; care being taken that the angles which the valve lever and wrist-plate rod make with each other are easy. In any case it is not advisable to make the angle between these points greater than 140° on the one extreme position, and less than 50° on the other. When these limits are reached in each direction, the angle moved through is about 90° , which is rather excessive. Nevertheless, continental engineers have frequently exceeded these limits, without experiencing any trouble in working. If the necessary movement cannot be obtained except by exceeding the above-named limits, the valve will have to be increased in diameter, or else a double-ported valve must be used. It should be stated that none of the above rules will suit all cases. The wrist-plate diagram is more one of convenience than of exact construction. If all the

* These rules are from the *Mechanical World Pocket Diary*.

angles are easy, and the valves give the necessary port opening, the designer may be satisfied as to its satisfactory working.

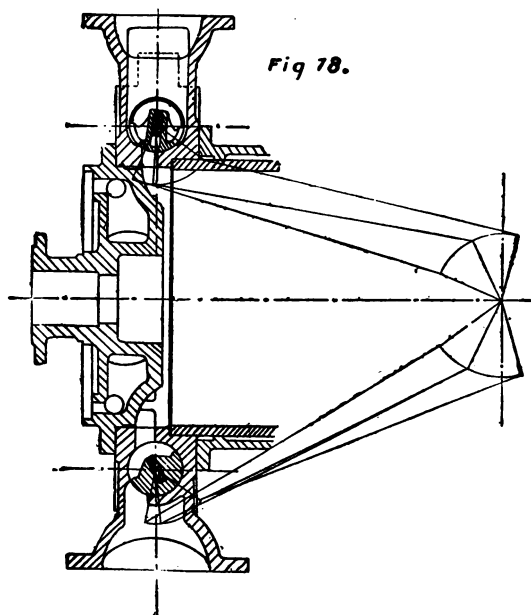
Position of Levers.—In arranging the exhaust-valve levers it is necessary to consider the position of the port. Two arrangements are shown in the following figures. In Fig. 77 the exhaust port is towards the centre of the cylinder. In opening, the valve moves in the direction of the arrow, and to give this action at the proper period the exhaust lever must have the position shown by the sketch. In the second case the exhaust port is remote from the



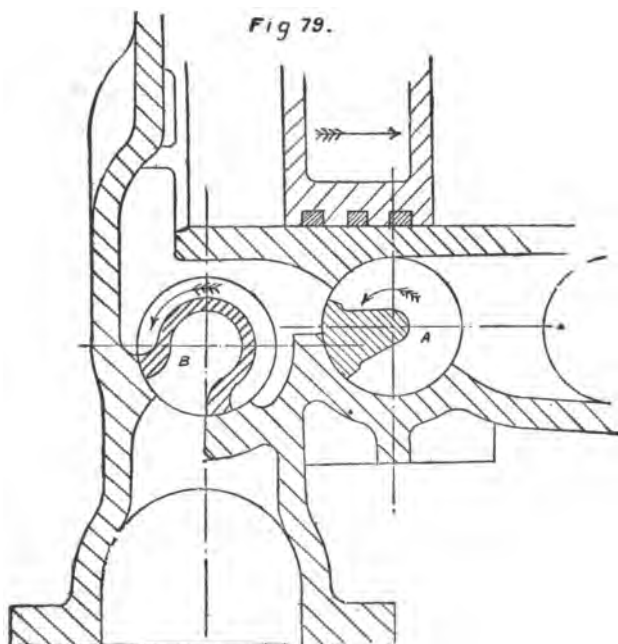
Position of Levers.

centre of the cylinder. This necessitates the valve lever being placed as indicated. Whatever the position of the port, the exhaust valve must be moving in the closing direction when the steam valve for the same end of the cylinder is opening.

Some Corliss engines have both steam and exhaust valves situated below the cylinder. This arrangement, although perhaps giving rather less clearance than the ordinary disposition of valves, is open to the objection that one port serves for both live and exhaust steam; a state of things not agreeable to the modern notion of economical working. The accompanying sketch, Fig. 79, shows



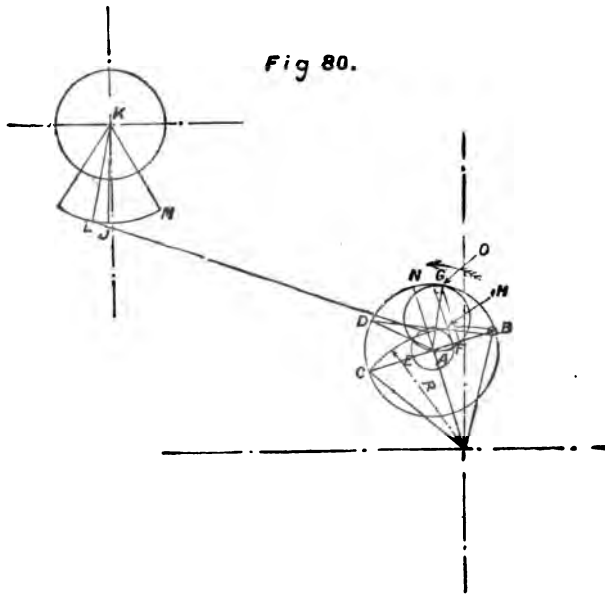
Position of Levers.



Arrangement of Steam and Exhaust Valves.

the valves disposed in this manner, wherein A is the steam, and B the exhaust valve. The latter is of the double-ported type in order to reduce the angular movement. The exhaust valve is arranged to drain the cylinder in a very efficient manner and thus obviating the use of drain gear. The relative positions of steam valve, exhaust valve, and piston are indicated, and the arrows show the direction of movement at this particular position.

Valve Diagram for Corliss Gear.—The amount of steam lap required to cut-off at any given point of the stroke is obtained in the manner shown by Fig. 80. Here R is the radius of the wrist-plate pin, and its central and extreme positions are marked A, B,



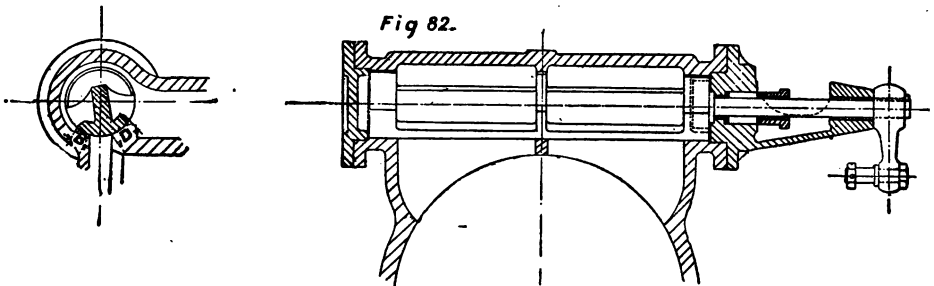
Valve Diagram for Corliss Gear.

and C. Draw the line BC connecting the extreme positions, and on this line as a diameter describe the circle. Imagine this circle to represent the path of the crank pin. Let it be required to cut-off when the crank is in the position AD, which in this instance is about 87 per cent. From B as centre, and with a radius equal to the lead, describe the circle. The line DB drawn as a tangent to the lead circle determines the lap circle EF. At F erect a perpendicular to meet the circle in G. The line FG crosses the radius line of the wrist-plate pins at H. H is the position of the wrist plate pin when the valve opens. From H, and with the length of the wrist-plate rod as radius, draw an arc cutting the valve lever radius at J. Then, in order to cutoff at the required point, the lap

any position of the crank is also known. Let OD represent the position of the crank at release. The corresponding position of the eccentric is CE ; the angle EOC being equal to the angle OAC , Fig. 80. Draw EF parallel to GC , cutting the wrist-plate pin arc in H . From H as centre, and with the length of the exhaust valve rod as radius, describe an arc cutting the valve lever arc in J . Draw KJ , which will be the position of the valve lever when release occurs. The central position of the lever is KL , and therefore the distance between the lines KJ and KL on the valve circumference indicates the amount of exhaust lap that is necessary to produce release at the pre-determined point. In the present instance the lap is of a positive character, and the exhaust valve closes the port by the amount obtained, when the wrist plate is in its central position. If the line KJ fell on the opposite side of KL , there would be clearance or negative exhaust lap, whilst the coincidence of these lines would denote that the port and valve edges were edge and edge, when the wrist plate was central.

If the length of the exhaust valve wrist-plate rods is adjustable, as it ought to be, the equalisation of release or compression for front and back strokes is a simple matter. This is most conveniently done when the engine is erected, and the eccentric coupled up. The exact lengths of the rods can then be obtained, and indicated by centre marks thereon.

Proportions of Steam Valve.—Fig. 82 shows the construction of a Corliss steam valve, and also indicates the proper dimensions

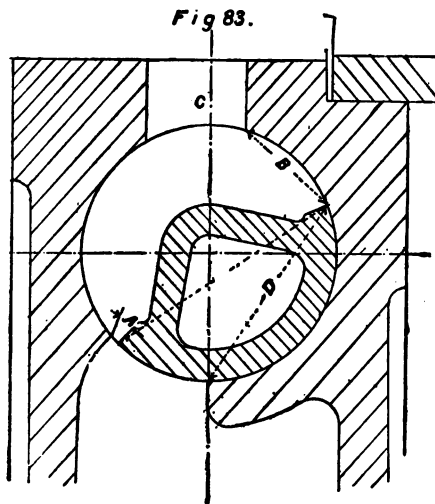


Proportions of Corliss Steam Valve.

of the face. The distance B is equal to the lap as found by the construction of Fig. 80. The dimension D must be sufficient to lap the back edge of the port when the valve is in its extreme position. D must therefore be equal to the dwelling movement taken at the valve circumference, *plus*, say, $\frac{1}{2}$ inch to insure tightness. The connection of the spindle with the valve is made by a palm forged on the spindle, and fitting into a recess at the end of the valve. This construction allows the valve to bed to its face and follow up any wear, and at the same time permits the valve spindle to work in its bearings without constraint. The spindle is shown provided with a stuffing box and packing gland.

This is the most usual construction, but in many cases the packing is dispensed with altogether; the valve spindles being made to work in long bushes accurately bored to suit them. In practice, this method of construction is very satisfactory, and valve spindles thus fitted have been known to run many years without permitting a breath of steam to escape. It is certainly the more mechanical arrangement, and when once in order requires no attention. The friction of a stuffing box is always an unknown quantity, and at times may become excessive and cause undue stress on the pins.

Proportions of Exhaust Valve.—A section of an exhaust valve is shown by Fig. 83. The negative lap is indicated by A. B must not be less than the active angle of movement taken at the valve circumference, otherwise the valve will close the port C, and



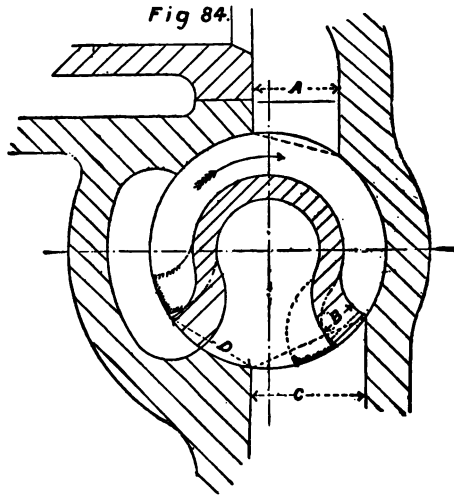
Section of Exhaust Valve.

the exhaust will be throttled. D should be a little more than the movement of the valve circumference during dwelling period, in order that the valve may not re-open the port by its back edge.

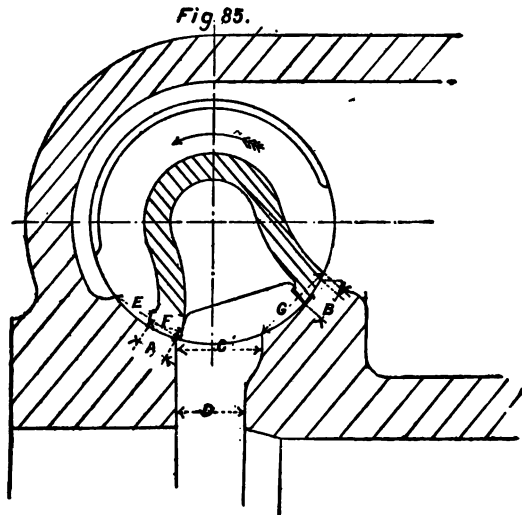
Double-Ported Valves.—If desirable, the exhaust valves may assume the double-ported form. This type permits of a considerable reduction of travel compared with the single-ported valve. With most English makers it is customary to make both steam and exhaust valves the same diameter, and when the angle of movement for the steam valves is great, it may happen that the requisite angle for the exhaust valves will be still greater and exceed the limits for safe working. In cases of this sort a double-ported valve is convenient.

The annexed figure illustrates the double-ported Corliss valve; the correct dimensions for the face are as follows:—A is the width of

the port in the cylinder. The width of the valve face B is empirical. Then the width of the exhaust port $C = A + B$. D not less than



Double-Ported Corliss Valve.



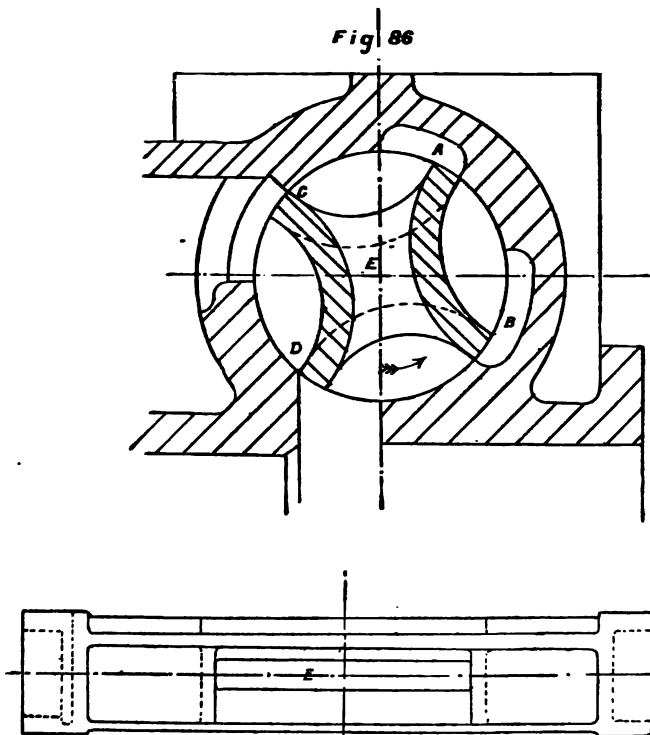
Proportions of a Double-Ported Corliss Valve.

the movement of the valve circumference during dwelling angle, plus an amount for tightness. The arrow denotes the direction of

the opening movement, whilst the dotted lines show the position of the valve when full open. The valve should be designed to take up as much of the chamber as possible without wire-drawing the steam, so as to reduce clearance.

The double-ported form may, of course, be applied to the steam valves, and this is often done in large sizes. The form and proportions of such a valve are here shown. A and B are equal to the lap as found by construction. The width of the port at D is what would be necessary for a single-ported valve; but at C the width is $D + F$, so as to maintain a full opening. E and G should be equal to the movement of the valve circumference during dwelling angle, *plus* a suitable amount for tightness. The width F, as before, is determined by practical considerations.

Equilibrium Corliss Valve.—In order to still further reduce the travel the form of valve shown by Fig. 86 may be employed.



Equilibrium Corliss Valve.

In opening, the movement is in the direction of the arrow, steam being admitted at the openings A and B as well as at C and D.

88701

The opening E extends for half the length of the port in the cylinder, as is shown by the elevation view. It is strange that this valve is so little known, or, if well known, so little employed, for it has another advantage besides that of reduced travel. An inspection of the figure will show that at all points the valve is in perfect equilibrium, and that the only resistance to motion is caused by the friction due to the weight of the valve and the friction between the valve spindle and its stuffing-box. It may be objected that because of the peculiar form any wear that takes place cannot be taken up; but where there is no friction there can be little wear, and in practice the valve has proved a success. Its use entails rather more clearance than the ordinary type, but if the valves were placed at the ends of the cylinders, instead of at the top and bottom, in the usual manner, the clearance would still be less than that of most Corliss engines of the present day. It should be added that an engine fitted with this form of valve on the high-pressure cylinder was exhibited at the Paris Exhibition by MM. H. De Ville-Chatel & Co.

Crank-Shaft Governors applied to Corliss Valves.—The combination of a crank-shaft governor and Corliss valves forms a very good arrangement, but one which has not found much favour in this country. The action of crank-shaft governors having been discussed in the first part, further description is unnecessary. It may be necessary to state, however, that the governor must alter both the angle of advance and the throw of the eccentric, in order that the lead shall be constant. A governor of the form shown in Fig. 44, Part 1, will not do; but the Westinghouse governor, Figs. 46 and 47, Part 1, is particularly suitable. It is advisable to employ a separate eccentric for the exhaust valves, so that compression may not be excessive when the engine is running light. The separate eccentric also relieves the governor to a considerable extent.

The annexed illustration shows an engine cylinder with Corliss valves; the cut-off being controlled by a crank-shaft governor. In this case, the valves are located in the covers, and are of the balanced type just described. Separate eccentrics for the steam and exhaust valves are employed; and wrist plates, as will be noticed, are dispensed with; each valve receiving its motion direct from a rocker arm to which the eccentric-rod is connected. This valve gear is specially suited for high-class quick-running engines. It has the simplicity of slide valve gearing without the concomitant defects of the latter; and, for quick running, has advantages over ordinary Corliss gears which will be fully understood when trip gears have been dealt with. The steam branch is below the cylinder; steam passing through a belt cast with the cylinder to the "E" pipe, and thence to the steam valves. The exhaust branches are below, and serve as feet by means of which the cylinder is secured to the foundations.

Diagrams of Valve Motion.—The accompanying diagrams

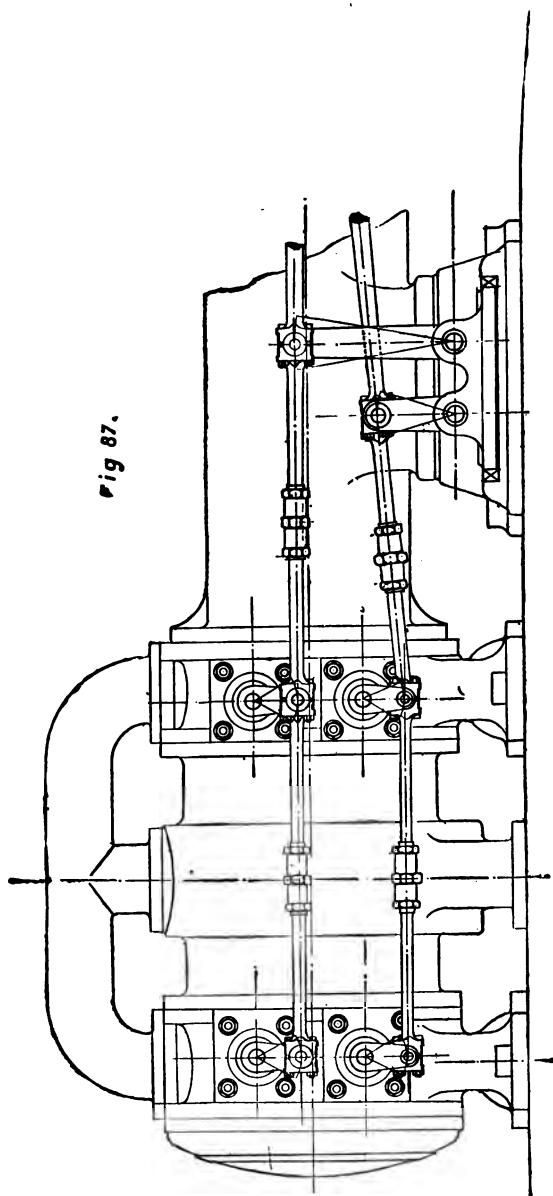
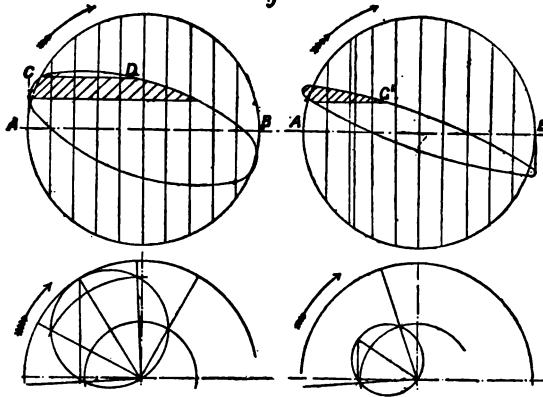


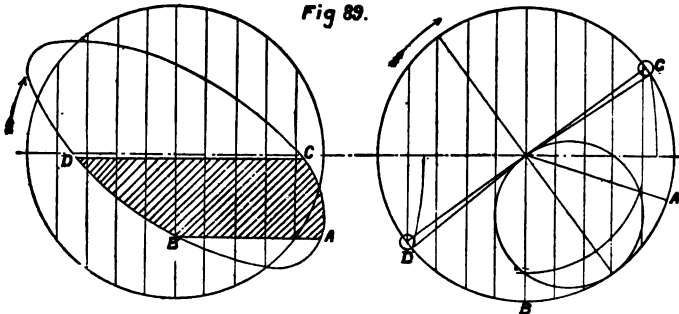
Fig 87.

Engine Cylinder with Corliss Valve.

illustrate the action of the steam valves. The horizontal axis *A B* represents the stroke of the engine; whilst the extreme width represents the travel of the valve. The stroke is divided into ten equal parts, and the points at which these divisions intersect the

Fig 88.

diagrams show the distance of the valve from its central position. The shaded portion shows the port opening, and the fact of the diagram passing beyond the line *CD* denotes that the valve has over travel. In the left-hand diagram the valve has its maximum travel, and the point of cut-off, *C*, is latest. At the earliest cut-off,

Fig 89.

the diagram assumes the form shown by the right-hand figure. The lap, of course, remains the same, but the travel is reduced, and cut-off is consequently at *C'*. Below the ellipse diagrams are shown the steam distributions for the early and late cut-off by Zeuner's method.

The diagrams for the exhaust valves are shown in Fig. 89, from which it will be seen that the valves have over-run; consequently, the port is full open at *A*, and remains so, until *B* is reached. Release and compression are at *C* and *D* respectively.

This description concludes the remarks on Corliss gears without trip motions.

CHAPTER II.

SINGLE ECCENTRIC GEARS WITH TRIP MOTIONS.

CONTENTS.—Principles of Trip Gears—Advantages of Trip Gears—The Reynolds Trip Gear—Diagram showing Range of Trip—Diagram for Reynolds Trip Gear—Clearance of Catches—Movement of Trip Levers—Cause of popularity of Corliss Gear in America—Arrangement of Link-work.

Principle of Trip Gears.—The class of Corliss gears fitted with trip motions has now to be considered. In mechanisms of this description, the steam valves are not in positive connection with the eccentric, but are moved by it against the resistance of a spring, weight, or vacuum. The eccentric-rod, or some other rod connected thereto, is provided with an arrangement whereby it engages with the valve lever, and communicates its motion to the steam valves in the opening direction only. This engagement is broken at a certain position in each revolution, determined by the governor, or by hand, and the valve, freed from all connection with the eccentric, is at once closed by the springs or whatever may be employed for the purpose.

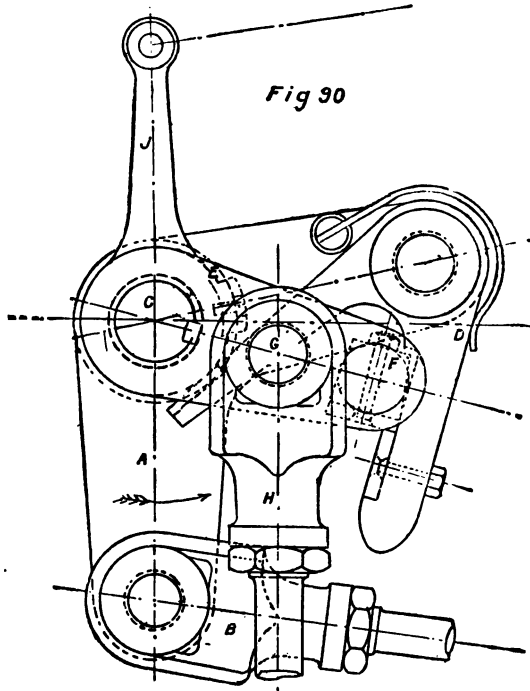
Advantages of Trip Gears.—The arrangement just described has several important advantages. The first and most valuable is the way in which the governor controls the engine; cutting off steam at the point requisite to maintain a uniform speed, and doing so in a manner that relieves it of almost all influence due to the valve; the function of the governor being, not to close the valve, but to determine when it shall be closed.

The second advantage that trip gear possesses is the practically instantaneous cut-off that results from its operation. The steam valves, as previously remarked, are opened against a resistance, which, at the proper instant, closes them with a rapidity and precision altogether unattainable by any motion derived from a reciprocating or rotating part of the engine. This cut-off, indeed, is so rapid, that an indicator diagram from a cylinder fitted with trip motion and receiving boiler steam can always be distinguished by the sharp corner at cut-off.

The Reynolds Trip Gear.—As a typical example of trip motion the Reynolds gear is selected and illustrated by Fig. 90. This gear is the invention of Mr. Reynolds of the E. P. Allis

Company, Milwaukee, America, in which country it is most common. The patent right of the invention having expired any one is at liberty to manufacture the gear.

In Fig. 90 the double-ended lever A, to which the wrist-plate rod B is connected, swings loose upon the valve spindle C. This lever carries on its upper end a trip hook D, supported by a pin fixed in the lever A. The lever E is keyed on the valve spindle, and thus imparts any motion which it may receive to the valve. F is a square pin fixed in the lever E, and fitted with a steel catch or



Reynolds Trip Gear.

face as shown by the figure. On the lever E, and between the valve spindle C and the square pin F, another pin is provided. This pin G has a continual downward force exerted upon it by the dashpot through the medium of the dashpot-rod H, and will, therefore, unless prevented, always occupy its lowest position. A steel catch on the trip hook engages with the steel catch on the pin F; and while this engagement holds, any movement of the lever A in the direction of the arrow will draw up E through the medium of the trip hook, and E, being fast to the spindle, moves the valve. It will be seen that if by any means the catch on F becomes released

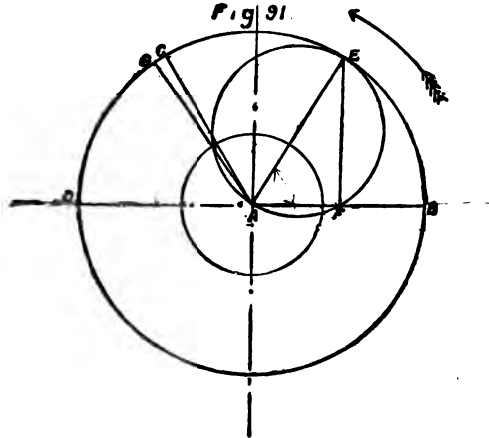
from the trip hook, the lever E will at once descend to its lowest position, and in so doing close the valve. It only remains to devise a means of effecting the disengagement at any desired instant, and the essentials of a trip gear are obtained. The method of accomplishing this disengagement is as follows:—The lever J, situated between the levers A and E, is loose upon the valve spindle. On the boss of this lever is a steel piece which projects above the surface of the boss. The inner limb of the trip hook rests upon this boss, being kept in position by the steel spring K encircling its upper half. During the motion of the wrist-plate lever A in the direction of the arrow, the trip hook is carried up, and because the steel catch thereon engages with the catch on the dashpot lever E, the latter also rises. This state of things will continue until the limb of the trip hook strikes the steel piece on the boss of lever J, when the hook is caused to oscillate upon its pin, and in so doing forces the steel catch clear of the catch on the dashpot lever, which is at once dragged down by the dashpot. From a consideration of the motion it will be seen that there is a sort of sharpening action on the catches when at work, whereby the edges remain in good condition for a considerable period. The steel catches are secured to their respective levers by small bolts as shown, and are sometimes designed so as to be reversible, thus presenting eight edges for wear.

It is clear that by varying the angle of the trip lever the position of contact of the projecting piece thereon with the limb of the trip hook is also varied; and it is also clear that if J be connected to the governor in a suitable manner, the latter will have control over the cut-off by determining the point at which the lever E is released.

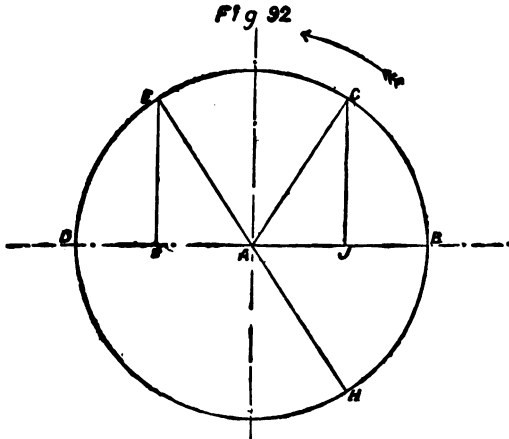
Diagram showing Range of Trip.—A study of Fig. 90 will reveal one important fact—namely, that tripping can only take place when the wrist-plate lever is moving in the opening direction. This statement is common to so many gears that it may be laid down as a rule.

Let A B, Fig. 91, represent the crank of an engine, and A C the eccentric having an angle the cosine of which is equal to lap *plus* lead. As drawn, the engine is on the back dead centre, and the steam valve at that end of the cylinder would be open to lead. The eccentric is moving the valve in the opening direction, and will continue to do so until it reaches A D. The angle of advance C A B is unaltered, and, therefore, when A C is at A D the crank is at A E, angle D A E being equal to angle C A B. The eccentric now returns, and unless the trip has operated before this return motion has commenced, it will not do so during that stroke. Therefore, with an eccentric set in the position A C, the total range of tripping is only from B to F, in this instance about 25 per cent. of the stroke. Such a range, however, is scarcely suitable for many cases, where it may be requisite on heavy loads to carry on steam to 50 or 60 per cent.;

and at other times, when running light, to say 20 per cent. only. With the setting shown by Fig. 91, if the trip missed, steam would carry on till the crank reached A G, the valve then cutting off by virtue of its lap. Thus it is seen that between A E and A G the governor has no control over the steam.



Now take the case of an eccentric set in the position A C, Fig. 92. The letters in this diagram correspond with those in the previous figure. Here it is evident that the range of trip is considerably increased, being now B F, about 78 per cent. When



the crank is at B, the valve is open to lead as before, but when the eccentric is in this position, the crank will be at A H, angle H A B being equal to angle C A B. In order to give the desired amount of lead, the valve must cover the port by an amount equal

with the projecting piece just touching the trip hook, and this will be its position at latest trip.

The method by which the trip levers for each end of the cylinder are made to move equally in opposite directions is clearly shown in

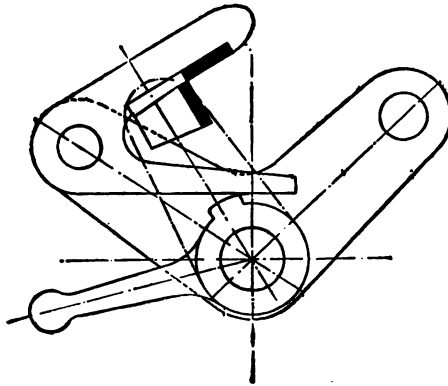


Fig 94.

Movement of Trip Levers.

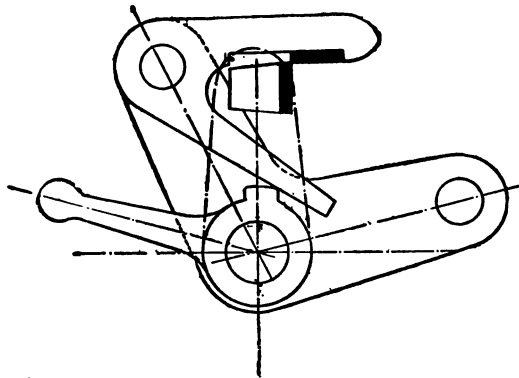
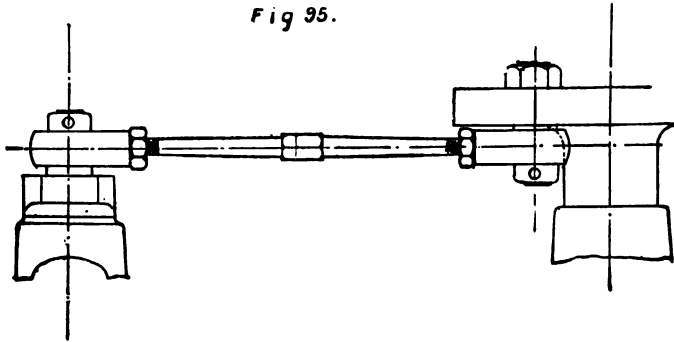


Fig. 93. With reference to this matter, it will suffice to say that P is a fixed centre of motion, and the governor actuates the double-ended lever swinging on centre P. A pointer may be attached to this lever playing over a graduated index, so that the point of cut-off is always seen.

Cause of Popularity of Corliss Gear in America.—In America, Mr. Corliss employed only one eccentric to operate both steam and exhaust valves; an arrangement whose very defect has perhaps contributed more to the popularity of Corliss gear than anything else. The one eccentric precludes the possibility of cutting off after about $\frac{4}{10}$ stroke, which was little later than the most economical point for pressures then common. Whenever a Corliss engine was put down, it was imperative that it should perform its work within this range of expansion, so that the owner was unable to run his engine except under economical conditions. The advantage over those engines which were too small for their work was at once apparent, and gave rise to a common notion that the economy was due solely to the valve gear.

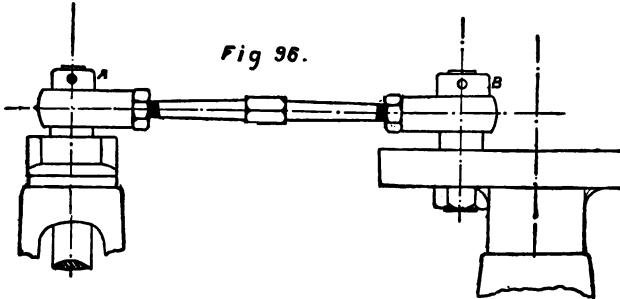
Arrangement of Link-work.—In designing the link-work of Corliss gears, it should be arranged that all rods can be taken off

Fig 95.



Arrangement of Link-work.


Fig 96.



Arrangement of Link-work (another method).

their pins by simply removing loose collars. This is a point sometimes forgotten, or at least neglected. In the arrangement shown

by Fig. 95, which is a plan view of a wrist-plate rod and its connections, it is evident that to remove the rod it is necessary to remove the rod from one of the sockets; whereas if it were arranged as shown by the next figure, the dismantling is effected by removing the two loose collars A and B. Then the length of the rod is not altered, and may therefore be replaced without any re-setting. These remarks apply to the governor trip rods, and in fact to all link-work of a similar nature.



CHAPTER III

DOUBLE-ECCENTRIC GEARS WITH TRIP MOTIONS.

CONTENTS.—Movement of Valves in Double-Eccentric Gears—Diagram of Motion—Speed of Trip Gears—Range of Trip—Proportion of Valves—Messrs. Musgrave's Trip Gear—Ingليس and Spencer's Slip Rod—Arrangement of Ingليس and Spencer's Trip Gear—Crab-Claw Trip Motion—Messrs. Ruston Proctor's Crab-Claw Gear—Dobson's Trip Gear—Valve Diagram for same—Mr. Goodfellow's Gear—Dashpots.

THE advantage of double-eccentric gears has already been commented upon. It remains to discuss the action of this class.

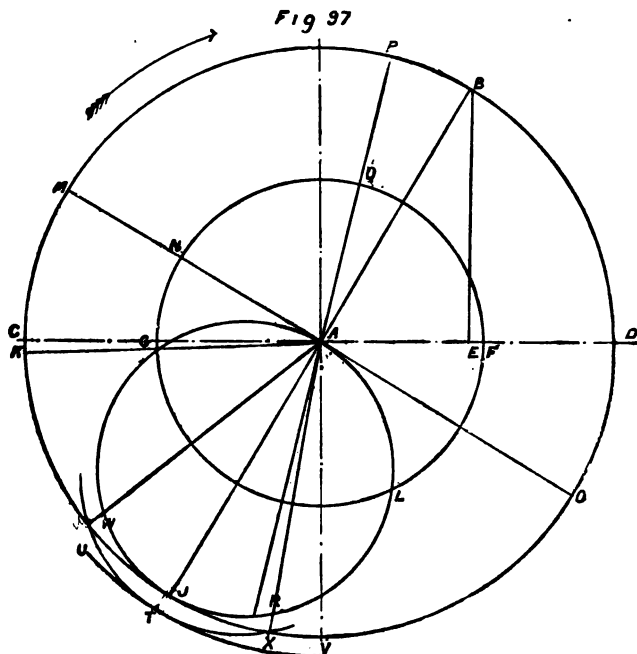
Movement of Valves in Double-Eccentric Gears.—The difference between the motion of a single- and double-eccentric gear is, that whilst in the single-eccentric gear the dwelling period of the steam valves occupies half the travel of the wrist plate, the steam valves of a double-eccentric gear have, strictly speaking, no dwelling period; all the motion of the valve lever being taken up by lap, clearance of trip edges, and port opening. The steam valves never lap the port by an amount greater than the lap; hence, other things being equal, a less movement of the valve lever is required than with a single-eccentric gear by the amount of dwelling angle referred to the valve circumference. It has been common practice to make the angular movement of double-eccentric steam valves from 60° to 70° ; and to make the port one-tenth the valve circumference. These are good rules, and, with an ordinary amount of lap, give sufficient over-travel to produce a full port opening early in the stroke.

The action of the steam valves will be understood from the annexed diagram and the following description:—

Diagram of Motion.*—The circle B C D (Fig. 97) represents the travel of the valve by its diameter, and the path of the crank pin by its circumference. Let the total range of trip be from C to E—that is, about 75 per cent. Draw E B perpendicular to C D, and from E mark off the lead E F. Then, F D is the necessary lap of the valve, and the position of the eccentric is denoted by the line A B, the crank pin being, by supposition, at D. Describe the lap circle F N L. Produce A B to J, and describe the valve circle A G J. The valve and lap circles intersect at G. From A draw a line through G, and produce it to the crank-pin circle. Then A K is the crank position when admission commences. From this point

* This adaptation of the Zeuner diagram was first suggested by Mr. James Dunlop.

the port opening continues to increase, and at crank position A M is equal to A N. A N is at right angles to B J, and the port opening for any position of the crank between A M and A O, in the clockwise direction, is given by an ordinate between the lap circle and the remote side of the valve circle. Thus, at A P the port opening is Q R, and so on. After A O, the port opening is indicated by the ordinate between the lap circle and the adjacent side of the valve circle. The lap and valve circles intersect at L. This denotes that the port is closed, and the diagram shows that it remains so till A K is reached. This would be the steam distribution if the valves were positively connected to the eccentric-rod



and operated without the intervention of trip gear, and it is seen that steam carries on to A L. Such a state of things is, of course, absurd, but it must be remembered that the trip gear releases the catches before the crank passes A B, and the valve at once closes, remaining stationary until re-engagement takes place.

Speed of Trip Gears.—It will have been noticed that engagement of the catches must take place twice during each revolution of the engine, and as the catches in many cases only move past each other $\frac{3}{16}$ or $\frac{1}{4}$ of an inch, it will be understood that there is not much time for engagement. In fact, it is well known that a speed of 100 revolutions is about the limit for trip gears. When this speed

is exceeded, missing of the catches is a likely occurrence. This is serious in a single eccentric gear, because steam carries on far in the stroke, and regular running is impossible, but in double eccentric motions it would be positively dangerous, inasmuch that a miss would cause live steam to flow through the exhaust, an occurrence not admissible under any circumstance.

In the previous figure let JT represent the clearance of the catches. With centre A and radius AT describe the arc UV . On AT as diameter, describe a portion of a circle cutting the valve travel circle in W and X . At X the catches are flush with each other. From X to T the clearance is being worked through, and at the latter point the valve lever is in its extreme position. From this point the catches approach one another and have re-engaged at W , at which point the valve begins to move. While the crank is passing from AX to AW the catches must re-engage or else a miss trip is the result. Take the case of an engine running at 100 revolutions per minute, and let the angle XAW be 30° . Under these conditions the time for re-engagement is only

$$\frac{60 \times 30}{100 \times 360}; \text{ that is } \frac{1}{20} \text{ of a second.}$$

It may be asked, why not give the catches more clearance to allow a longer time for engagement? The objection to this proposal is that more clearance would cause the engagement to occur at a time when the wrist-plate levers were moving at a comparatively high speed, and the inevitable result would be a considerable jar on the catches and wear on the pins. When the clearance is small, the eccentric is very near its dead centre when engagement takes place and is therefore moving the wrist-plate lever very slowly. The catches thus engage easily and without shock.

Range of Trip.—With respect to the range of trip that is most desirable, it may be stated that 75 per cent. is good and usual practice. If a less range will fulfil all requirements it may be adopted, but with the disadvantage of increased lap, which, to maintain the same port opening means increased travel, an objection which is compensated in some measure by full port opening being attained earlier in the stroke, as may be proved by construction. By increasing the range the lap is decreased, but the crank position at full port is later.

Proportions of Valves.—As there is no dwelling angle in the steam valves of double eccentric gears, it is sufficient to make the valve face lap the port on the back edge by an amount necessary for tightness and bearing surface when the valve is full closed.

The width of the face will therefore be—

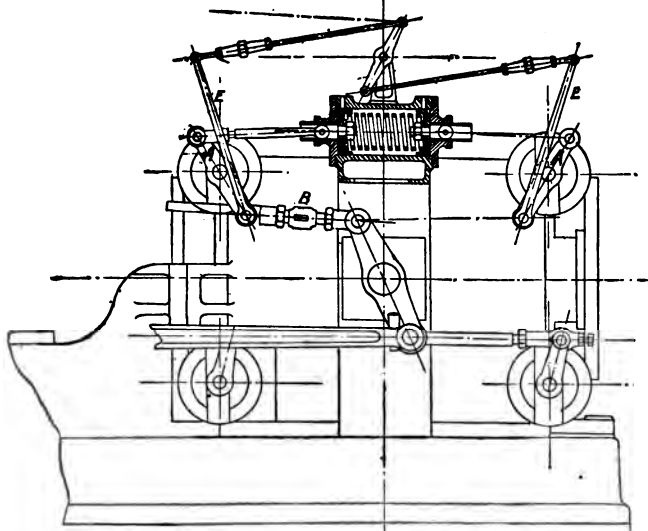
$$\text{Steam lap} + \text{width of port} + \text{back lap.}$$

The exhaust valves have dwelling periods, of course, like the single eccentric gears, the proportions for each case being exactly similar.

Messrs. Musgrave's Trip Gear.—The form of trip gear made

by Messrs. Musgrave, Bolton, consists of a valve lever A keyed to the valve spindle, and receiving motion from the rod B, which is provided with a steel catch. This catch engages with a steel piece

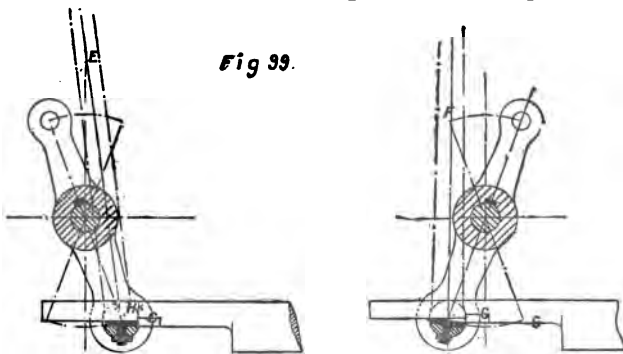
Fig 38.



Musgrave's Trip Gear.

on the valve-lever pin supported by the valve lever, but free to move therein. Connected to this spindle is the trip lever E, the

Fig 39.



Action of Catches in Musgrave's Trip Gear.

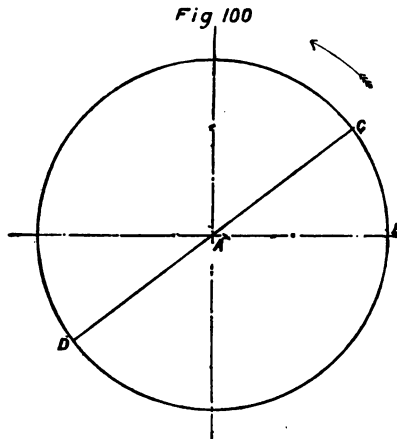
upper end of which is connected to the governor-rods in the manner indicated. The detail of the catches will be better seen in Fig. 39, in which the gear is shown in two positions when set for

the latest trip. At the left hand the catches have just engaged, and the valve begins to move from right to left against the resistance of the dashpot spring. The valve lever continuing its motion causes the steel catch on the spindle to gradually become disengaged from the catch C, because the upper end is held by the governor, and for any one stroke may be considered stationary. In the diagram to the right the mechanism is at the extreme position in the opening direction. The catches are edge and edge and the valve lever is about to be moved by the dashpot, and to occupy the position indicated by the dotted line F G.

The length of the trip lever E is regulated by the depth of engagement, the travel of the valve lever, and the width of the catch on the trip lever.

Let H = distance from centre to edge of catch (see Fig. 99).
 B = depth of engagement,
 C = length of trip lever,
 and D = travel of catch on trip lever,

Then, in order that trip may occur at the latest possible point, the equation $\frac{H}{O} = \frac{B}{D}$ must be satisfied. To find the depth of engagement at the beginning of the valve lever's motion in the opening direction, for any earlier point of cut-off, substitute D' for D, D'



being the movement of the valve lever from the commencement of its travel to the point at which trip shall take place. The value of B for the earliest trip determines the movement of the end of the trip levers, it being equal to—

$$C \left(\frac{B - B'}{H} \right).$$

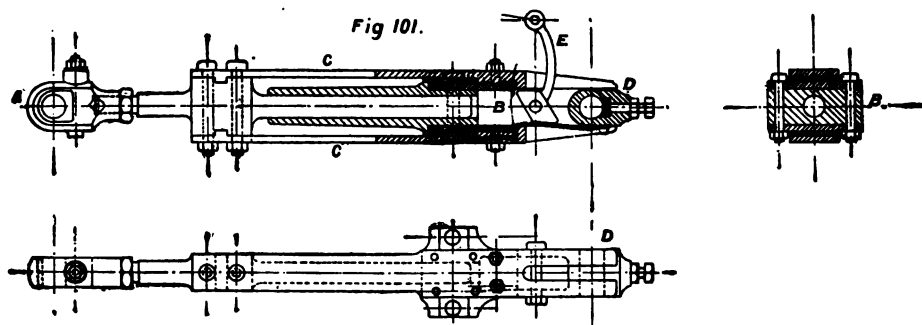
Here B' is the depth of engagement for earliest trip. The whole

matter is simply a question of leverage, the length of the trip lever being one arm, and the half width of the catch plate the other.

If the travel of the valves is large, the trip levers become inconveniently long, and to avoid this, Messrs. Musgrave usually employ double-ported valves, thereby reducing the travel.

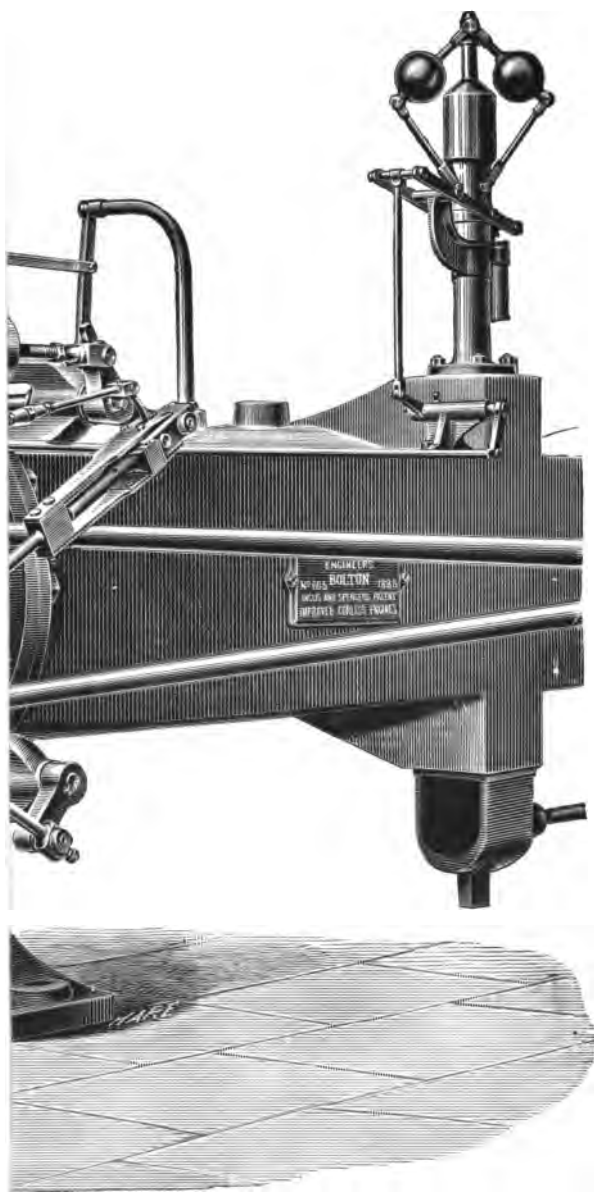
The arrangement just described is known as a "push" gear, because in opening the valve, the rod B is in compression. In push gears the eccentric must be directly opposite the proper position for a pull gear under the same conditions. Fig. 100 will illustrate the matter clearly. A B is the crank and A C the eccentric for a pull gear, but for a push gear A D would be the proper setting. The line A D is an extension of A B. It will be noticed that in Musgrave's gear the eccentric-rod connects to the wrist plate or its equivalent on the opposite side to which the valve-rods are coupled. This again alters the angle of the eccentric 180° , thus bringing it to A C, Fig. 100.

Inglis and Spencer Slip-Rod.—The well-known Inglis and Spencer slip-rod, the construction of which is shown in Fig. 101,



Inglis and Spencer Slip-Rod.

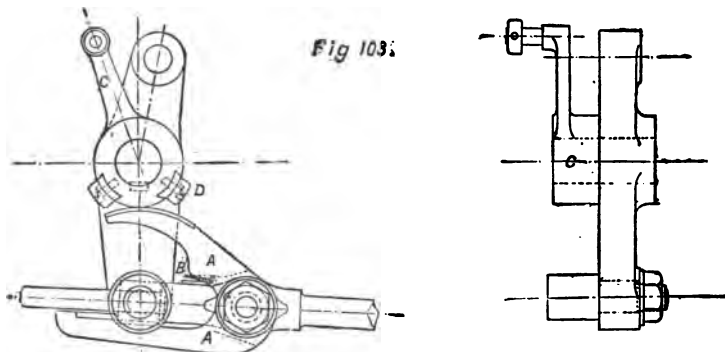
has established itself as a simple and reliable form of trip gear. The end A embraces the wrist pin and carries the spring clips O C, which are secured by bolts as shown. The end B telescopes on this piece, and is provided with steel catches to engage with the pieces on the clips. The eye D is coupled to the valve lever. Tripping is effected by the toe lever E forcing open the steel clips and releasing the catches. The upper end of the toe lever is under the control of the governor, and by its inclination to the slip-rod determines the point of tripping. It will be seen that when the slip-rod moves in the direction from B to A and the upper end of the toe is stationary, the result is to cause the head of this lever to move round on its centre, and in so doing force open the clips. The piece B then springs forward in consequence of the pull of the dashpot on the opposite end of the valve lever to which B is connected, and thus the valve is closed. The part B is then stationary,



but A, being connected to the wrist plate, continues its motion until the catches on the clips move past the catches on B, so that engagement takes place, and the whole rod moves together. To prevent noise during engagement the clips are provided with leather pads, which, falling on B, prevent any metallic click that would otherwise occur.

Arrangement of Inglis and Spencer Trip Gear.—The annexed folding plate shows the practical application of the above form of trip gear. The makers are Messrs. Hick, Hargreaves & Co., Bolton. Separate eccentrics and wrist plates are employed for the steam and exhaust valves, thereby allowing of a wide range of trip. The Inglis and Spencer slip-rod is clearly shown, and also the connection of the toe levers to the governor. The trip-rods are made to move in equal and opposite directions by toothed sectors fastened to the spindles on which the levers carrying the trip-rods are secured. These sectors, which do not appear in the engraving, are situated under the dashpot. The gear is shown set for the latest trip, the back steam valve is wide open, and the toe lever is about to release the clips in the manner previously described. The exhaust portion of the gear calls for no special remarks, being the usual arrangement adopted when wrist plates are employed.

Crab-Claw Trip Motion.—The crab-claw trip motion originated in America, where it finds much favour. The double-armed



Crab-Claw Trip Motion.

valve lever carries a pin provided with a square head of hardened steel, which engages with the lever limb of the distinguishing feature of this gear—the crab claw A. The wrist-plate rod passes through the square head and is free to slide therein. The claw is centred on this rod, and within certain limits is free to move on its centre. It is held to its place by the small spring B. The action of the gear is as follows:—Suppose the gear to be in the extreme position and about to move the valve in the opening direction. The crab claw then catches the square head fixed in the valve lever and thus pulls the valve open. This action will continue till

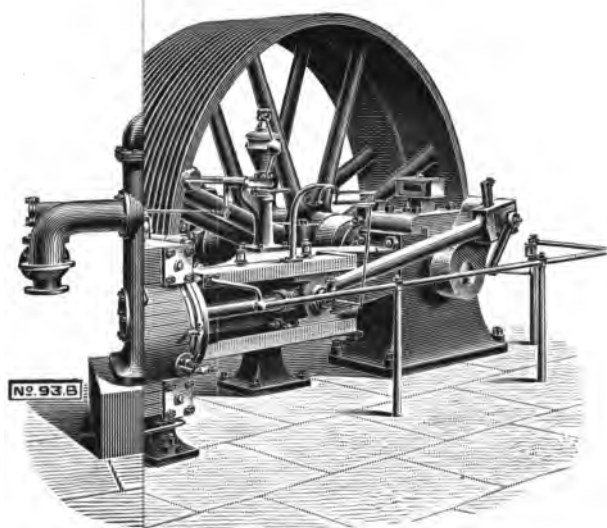
the upper limb of the claw strikes the projecting piece D on the governor lever C. The effect of this contact is to depress the crab-claw catch clear of the square head, and the valve lever being free, at once returns to its extreme position by the pull of the dashpot, and remains in that position until the crab claw returns to engage. The lever C is under the control of the governor, and by its position determines the time of liberation. The position of the crab claw centre for any point of the stroke being known, it is easy to find the position of D for any point of cut-off. As this matter was fully explained when describing Reynolds' trip gear, further explanation would be superfluous.

The second projection on the governor lever is for safety purposes. Should the governor driving-gear fail, the governor at once falls to its lowest position, and by moving the governor levers, brings the safety piece in contact with the claw and entirely prevents it from engaging with the square pin. The valve, therefore, remains closed, and the engine is soon brought to a standstill. The presence of the safety trip occasions a difficulty in starting; for the governor levers have to be held in a position to allow the claw to engage with the valve lever.

Messrs. Ruston Proctor's Crab-Claw Gear.—In England, Messrs. Ruston, Proctor & Co. employ the crab-claw gear, using separate eccentrics for steam and exhaust valves. Their practice is to carry the wrist-plate centre above the central line of the cylinder, if necessary, so as to bring the wrist-plate rods practically horizontal; and to locate the steam wrist-plate pins as near the vertical centre line of the wrist plate as the rod ends will permit.

Fig. 104 is an illustration of one of this firm's twin-compound condensing engines, fitted with crab-claw gear.

Dobson's Trip Gear.—Dobson's trip motion is illustrated by Fig. 105. The sliding piece A is carried by a bracket fixed to the side of the cylinder. This sliding piece receives its motion from the eccentric which couples to pin B. At each end of A are the trip boxes C, carrying tripping pieces E, and trip levers D. The latter are connected to each other and to the governor in the manner shown. At certain periods the tripping pieces engage with steel catches secured to the hollow spindle F, and by their engagement drag F and the dashpot piston secured thereto against the resistance of the dashpot spring. The upper ends of levers D are practically stationary, so that the effect of sliding A to and fro is to cause these levers to move on their centres, thus raising the tripping blocks and causing liberation. The cut shows the gear ready for tripping at about 25 per cent. of stroke. Any movement of the upper end of trip levers in an outward direction from the centre of the cylinder would delay liberation; whilst movement in an opposite direction would hasten it. The tripping blocks are held to their work by means of the light springs in the trip boxes, and are always pressed down upon the trip levers. The valve-rod



7 Gear.

is of rectangular section at the middle to enable the end to follow the arc described by the valve lever pin.

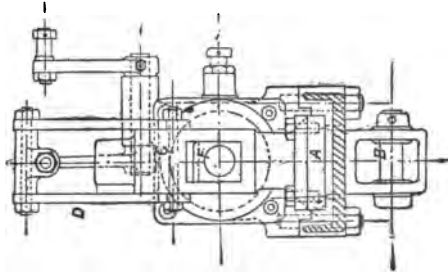
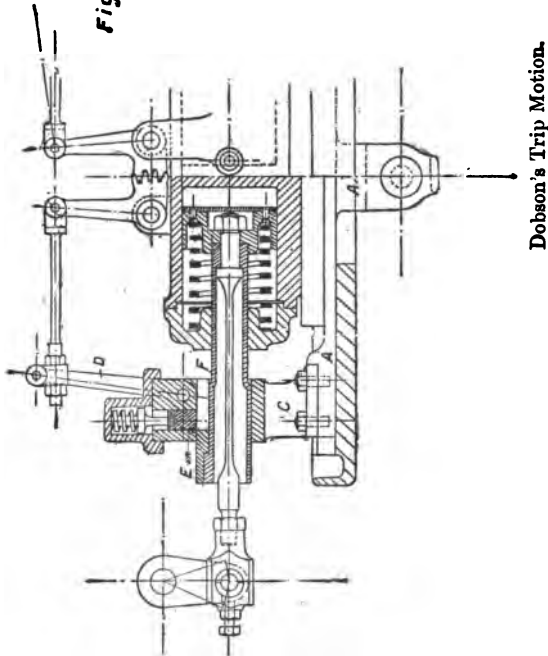


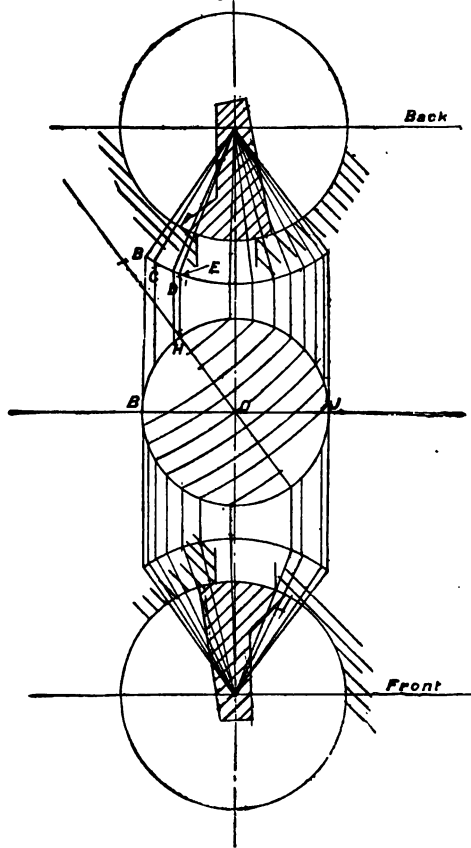
Fig 105.



Valve Diagram for Same.—The valve diagram shows the motion of the steam valves for both back and front ends. Starting at point B (Fig. 106) for the back steam valve, the motion from B to C is taken up by clearance of trip catches. Lap is then worked off and the valve opens, and at D the admission commences. From D to E on the arc of the valve lever is lead, and the projection of E to

the circle indicates the position of the eccentric when crank is on dead centre. Let *H* be the projection of *E*, and let *O H* be produced indefinitely. With centre on *O H* produced, and with a radius which bears the same ratio to the radius of the circle *B H J* as the connecting-rod bears to the crank, describe arcs for any convenient number of crank positions. Where these arcs intersect

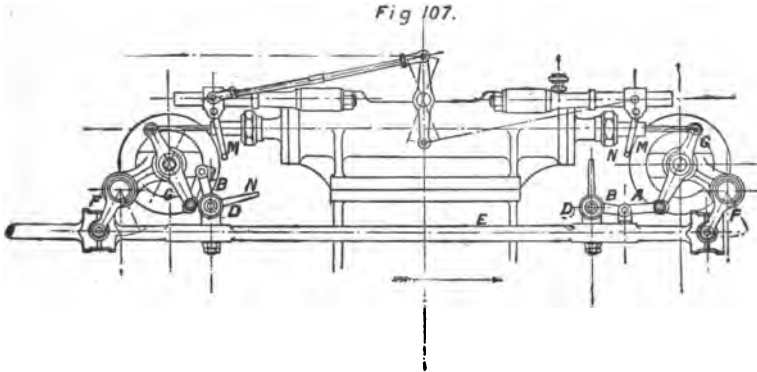
Fig 106.



circle *B H J* project lines to the arc of the valve-lever pin. (See the accompanying figure.) The port opening for any crank position is then at once read off. In the present case, the range of trip is seen to be from *J* to *H*, about 75 per cent. The port opening at one-tenth stroke is $1\frac{1}{2}$ inches; at two-tenths, $2\frac{1}{4}$ inches; at three-tenths, $2\frac{3}{4}$ inches; and so on. The unequal distribution due to connecting-rod influence causes the range of trip for the back stroke

to be somewhat less than for the front stroke. The diagram shows this. Messrs. Yates & Thom, Blackburn; Sharples & Co., Ramsbottom; and Victor Coates, Belfast, are constructors of Dobson's trip gear.

Goodfellow's Gear.—Benjamin Goodfellow, of Hyde, Manchester, constructs a trip motion in which catches are dispensed with altogether. In his arrangement, a knuckle joint is the device employed, and tripping is effected by the knuckle doubling up and leaving the valve to the influence of the dashpot. The rod E (Fig. 107) receives its motion from the eccentric-rod without the intervention of a wrist plate. The levers F F slung from brackets on the valve bonnets carry this rod, which is provided with a preparation for carrying a piece D. This piece forms the centre for the tripping finger. The double-ended valve levers C C are connected to the dashpot on one side, and to the piece D through the medium of the knuckle joint formed of the levers A and B. In the figure,



Goodfellow's Gear.

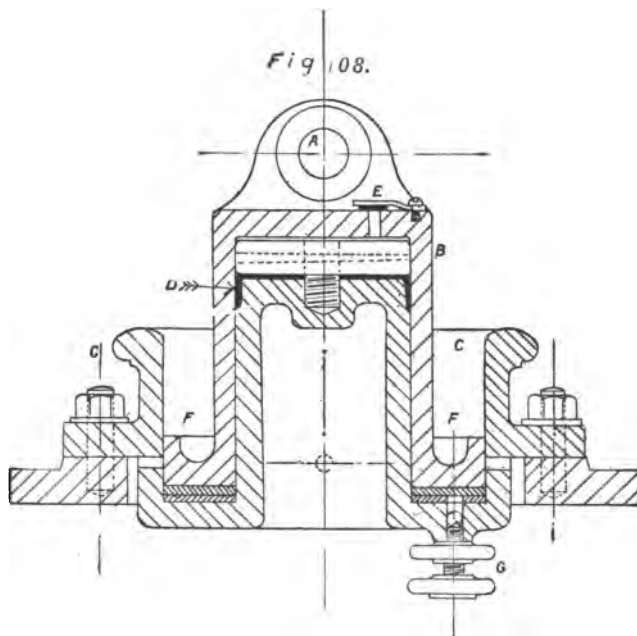
the gear is shown in the extreme position, and it will be seen that the knuckle for the back end is nearly straight. Any movement of E in the direction of the arrow will give an equal movement to the valve lever at the back end, because the central pin of the knuckle is slightly below the line connecting the two extreme pins, and the knuckle is prevented from doubling in a downward direction by a protuberance on the brass link A which rests upon the carrier rail E. The forward motion of the valve lever will continue until the tripping finger N, which forms part of the link B, comes in contact with the tripper M. When this occurs the knuckle at once closes up, and assumes a position similar to that shown at the front end. The trippers M are under the control of the governor, and by their position determine the point of cut-off. The hole in the brass link A is made larger than the pin of the valve lever which it embraces. The object of this clearance is to allow the centre joint of the knuckle to fall below the other joints, so as to

ensure no doubling up unless the trip finger is struck by the tripper. This play in the link corresponds to the clearance of ordinary trip gears. A leather pad on the link A deadens the noise when the gear attains its extreme position and the link falls on the carrier rail.

The method by which all plucking action on the governor due to the tripping lever striking the finger is avoided is very ingenious. The trip lever is hinged from the sliding collar, and is provided with stops on its upper end, which, whilst allowing the lever a little free play, prevent it swinging out of the way of the finger. The effect of M and N striking is not to slide the collar along the spindle and thus pluck the governor, but to cause the trip lever to bind on the under side of the sliding collar.

It will be convenient to conclude this chapter with a few remarks on dashpots.

Dashpots.—The vacuum dashpot shown by Fig. 108, rests upon a cast-iron plate secured to the engine foundations. The dashpot-

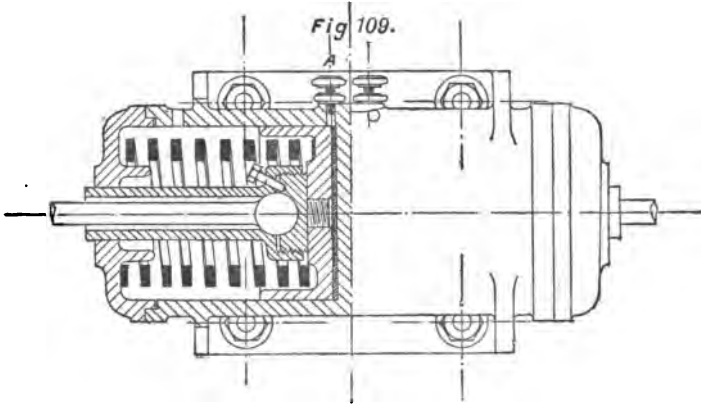


Vacuum Dashpot.

rod connects to the pin A, and lifts the plunger B, thus forming a vacuum between it and the casing C. Tightness is obtained by the leather ring D secured in position by a circular nut. The small valve E is free to move in one direction only, and allows air to escape from the vacuum chamber into the atmosphere. F is the

cushion chamber, the object of which is to prevent the dashpot closing violently. The cushion part of the plunger is provided with a leather pad which falls on a pad fastened to the bottom of the cushion chamber. When the piston descends, the small valve G regulates the escape of air from the cushion chamber with the greatest nicety, and renders the action practically noiseless.

The diagram of the spring dashpot is self-explanatory, and it only remains to say that the valve A regulates the cushioning of the piston in the manner already described.



Spring Dashpot.

A vacuum dashpot is not suitable for a double eccentric gear, because the small movement of the valve lever from engaging position to admission point does not raise the plunger sufficient to produce a good vacuum. There must be some clearance in the vacuum chamber, and therefore the degree of rarity of the atmosphere therein is proportional to the lift. In double eccentric gears the valve movement for early cut-off is very small, and is insufficient to secure prompt action of the dashpots; but with single eccentric gears, the dwelling and lap angles must always be worked through before steam opens, so that even at the earliest cut-off the dashpot lever lifts a considerable amount. With a spring dashpot, an initial tension or compression can be given, which will close the valves promptly at all grades of expansion.

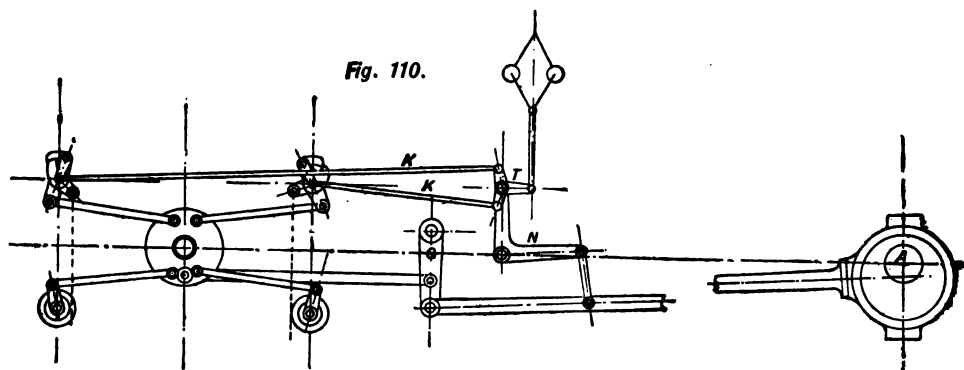
CHAPTER IV.

SINGLE ECCENTRIC GEARS WITH LARGE RANGE OF TRIP.

CONTENTS.—Frikart Single Eccentric Gear—Valve Diagram for Frikart Gear—Farcot Gear—Features of Cylinder—Wheelock Gear—Conclusion.

It remains to illustrate and describe several gears which form exceptions to the rule that tripping can only take place when the eccentric is moving in the opening direction.

Frikart Single Eccentric Gear.—The first gear to notice is that invented by Frikart, and made under license by Messrs. Greenwood & Batley, Leeds. The peculiarities of this gear permit of



Frikart Single Eccentric Gear.

both steam and exhaust valves being operated by one eccentric, whilst giving a range of trip up to 75 per cent., or even later. Another advantage is that in consequence of engagement being positive—that is, not relying upon springs to bring the catches into gear—the motion is adapted to speeds quite unsuitable for ordinary trip gears.

In order to understand the action of the trip itself, it will be necessary to consider the arrangement of the rods and levers. In the diagrammatic sketch, Fig. 110, A is the crank shaft on which is keyed the eccentric, giving motion to the wrist plate through the swing lever G. The wrist plate communicates its motion to the exhaust valves in the usual manner; but the steam valves derive their motion through the medium of several levers. The detail of

the trip is shown by Figs. 111 and 112. The two levers A and B oscillate upon the valve spindle, the wrist-plate lever A being loose, and the dashpot lever B keyed on. Swinging on the upper end of A is the tripping lever and catch C, which, at certain periods,

Fig. 111.

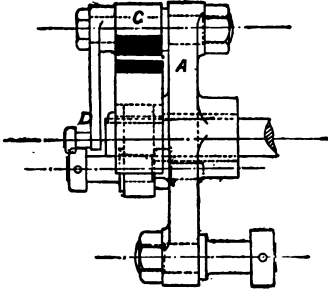
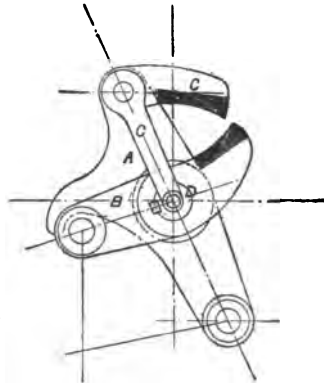


Fig. 112.

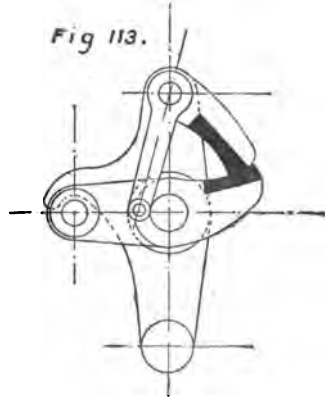


Frikart Single Eccentric Gear.

engages with the dashpot lever. C is so constructed, that when the centre of the pin D coincides with the centre line of the valve spindle, the dashpot lever is free to descend and cut off steam. Fig. 113 shows the gear in another position, where the centre of the trip lever pin is not coincident with the centre of the valve spindle; and where the dashpot lever is being raised because of the engagement of the trip lever with it.

Reverting now to Fig. 110, the motion of the trip levers will be understood. From a suitable point on the eccentric-rod, the lever N receives motion. N in turn operates the levers K by means of the three-armed lever T. The governor connects to T by means of swinging links, and by its position determines the inclination of the three-armed lever. The latter has a constant motion from the eccentric-rod, so that the governor does not regulate the amount, but simply the position of that motion. The levers O are thus seen to be under the influence of three movements. In the first place they are carried round by the wrist-plate levers; the second motion is derived from the levers K; whilst the governor, as before stated,

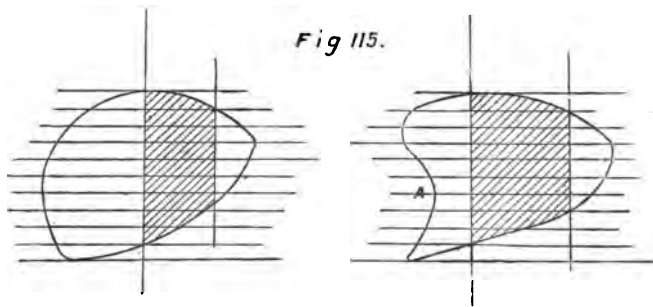
Fig. 113.





which in this instance falls on the line A E. Tripping now takes place at A E, the point where the valve closes by virtue of its lap and movement from the wrist plate. This is, therefore, the latest trip. Suppose the governor rises and moves the trip levers in the opposite direction. Then the intersection of the circle whose radius equals the amount of displacement with the polar circles indicates the position of cut-off. In the diagram, A J represents the displacement, and tripping is seen to be at A K.*

Diagrams of the movement of the steam and exhaust valves are given by Fig. 115; that to the left being the steam diagram, and the right hand the exhaust. Referring to the steam diagram, it is seen that full port opening is attained at 10 per cent. in the stroke; a result which must be considered very satisfactory. The peculiar concavity of the exhaust diagram at A indicates that the disposition of the wrist-plate pins and exhaust



valve-rods is faulty, insomuch that there is a double reversal of stress on these parts. The diagrams owe their irregular form to the presence of the wrist-plate, which modifies the motion so that the valve movement is no longer represented by an ellipse.

Farcot Gear.—The Farcot gear is another example of a single eccentric motion giving a wide range of trip. This gear was illustrated and described in *Engineering* some time ago, and the following description and cuts are taken from that source. (See Folding plate):—

“The general arrangement of the valve gear is shown by Fig. 116, while Figs. 117 to 120 represent the cut-off gear in detail. As will be seen from the general view, but one eccentric is used, this giving motion to a wrist-plate, which is connected by rods *c* to levers *d* mounted loose on the admission valve spindles (see Figs. 117, 118, and 119). The lower part of each lever *d* carries a catch *f* which is constantly drawn towards the valve spindle by a spring. Upon the valve spindle is keyed an arm *g*, which is acted upon by a spring tending constantly to close the valve, and which, on the other side of the valve spindle, carries a steel catch plate *h* (Fig.

* This diagram is due to Mr. James Dunlop.

118), arranged so as to engage with the corresponding steel plate *j* carried by the catch *f*. It will be readily understood how by this arrangement the oscillation of the lever *d* in one direction gives an opening movement to the valves, while the closure of the latter under the pull of the spring connected to the arm *g* will evidently take place whenever the steel plates *j* and *h* are disengaged from each other.

"The disengagement of the catches *h j* is effected, under the control of the governor, by an ingenious arrangement, which we shall now describe, and which permits of the cut-off being varied from zero to 80 per cent. of the stroke. In the ordinary Corliss gear it will be remembered that the detachment of the valve must take place while the latter is opening, and thus, if detachment has not taken place before the valve is fully open, the admission goes on to the full extent permitted by the undetached valve. In the Farcot gear, on the other hand, the detachment may take place on either the opening or closing strokes of the valve, the means by which it is effected being as follows:—On the boss through which each admission valve spindle passes, are mounted two cams *k k'*, as shown by Figs. 117, 119, and 120; these cams being coupled by the links *l l'* to one arm of a bell-crank (see Figs. 116 and 117), the other arm of which is connected to the governor. The projections on these cams act upon the detent *f* as follows:—The projection of the cam *k* acts directly on the finger *m* (Fig. 120) and serves to lift the detent *f* and release the valve during the opening stroke of the latter, thus cutting off the steam at any point from zero up to about 35 per cent. of the stroke; the cam *k'*, on the other hand, acts upon the movable finger *n*, and serves to release the valve during its closing stroke, thus cutting off the steam at from about 35 to 80 per cent. of the stroke.

"Referring to Fig. 120, it will be seen that the finger *n* slides within *m*, and is pressed out by a spiral spring. During the opening stroke of the valve, *n* is pressed within *m* by its end coming into contact with an inclined surface on the cam *k'* giving the longer admissions. In this way the cam *k'* is prevented from interfering with the action of the cam *k* when the engine is working with short steam admissions. On the other hand, when the opening movement of the valve has taken place sufficiently far, the projection on *k'* completely passes the finger *n*, and the latter is then forced out by its spring ready to engage with the projection of the cam *k'* during the return stroke of the valve.

"The wearing parts of the gear we have been describing are of simple form, and are readily renewable, while, being made of hardened steel, the wear on them is exceedingly small. As compared with the Farcot gear exhibited in 1878, that now described has the advantage that the arrangement for giving late admissions is not in continual use. When working with the short admissions usual with this class of engine, the finger *n* remains projecting freely from *m*, and it is only thrust back within the latter when longer admissions

are required. The slopes of the cams k and k' also being very gentle, exceedingly little work is thrown upon the governor.

"A special arrangement of one of the cams also prevents the engine from running away in the event of the governor breaking down, this cam shutting off the steam completely in the event of the governor stopping and the balls closing. It will be noticed on reference to our detail views that the valve spindles are without stuffing boxes, they simply working in well-fitting gun-metal bushes fitted to the bosses through which they pass."

Features of Cylinder.—A section of the cylinder is shown by Fig. 121. The endeavour to reduce clearance by placing the valves in the covers will be noticed and appreciated. The steam-jacketing is a special feature of this engine; and an inspection of the figure will show that the covers are also constructed to give ample space for boiler steam.

A point to which exception may be taken is the double reversal of stress on both steam and exhaust rods and wrist-plate pins, due to the particular location of the latter; but this point has evidently been subordinated to that of keeping the dwelling angles as small as possible. That there is a double reversal of stress on these parts is apparent from the general view of the engine.

Wheelock Gear.—As another example of a single eccentric gear giving a wide range of trip, the Wheelock gear may be cited. The rods which actuate the trip levers receive their motion from the eccentric in a similar manner to the Frikart gear. The governor determines the position of the motion of the tripping piece, but not the amount, that being constant at all times. Strictly speaking, the valves are not of the Corliss type, but consist of multiple-ported grid valves working on a flat face. This face is formed on a conical plug of special hard metal forced into suitable taper holes in the cylinder. The connection of the spindles with the valves is through the medium of a toggle joint, situated inside the valve chamber, a device which has the advantage of giving a rapid opening motion; a good feature usually purchased at the expense of a wrist plate. Messrs. Daniel Adamson & Co., Dukinfield, are manufacturers of the Wheelock gear.

Conclusion.—There are numerous other varieties of trip gears, but as they are all pretty much on the same lines as those already described, it will be unnecessary to describe them. A knowledge of a few good and well-known types will enable the action of others to be understood, and their merits and demerits appreciated. Although many makers seem resolutely to adopt one style of gear, and use it to the exclusion of all others, the advantage of one gear over another is but slight, and it may be taken that, given good design and workmanship, it is immaterial which gear is selected, because the above qualities ensure satisfactory operation to most types.

Extensive as is the use of Corliss gear, it has not yet been employed in all cases where it would be advantageous. Marine

engineers, although striving in many ways to reduce weight and steam consumption, have so far neglected the Corliss valve, but if further economy is to be looked for, the Corliss valve undoubtedly offers a means of attaining it ; and with the ever upward tendency of steam pressures its advantages will become more pronounced. The chief difficulty with which the marine engineer will have to contend will probably be the arranging of the gear in a compact and accessible position, so that the valves may be drawn out for inspection, without unshipping more parts than is absolutely necessary. Trip gear, of course, will be dispensed with, the valves having lap equal to a slide valve under similar conditions. Joy's radial valve gear, or some other similar contrivance, would perhaps be preferable to link motion, for reasons which will be apparent from a comparison of the two arrangements.

PART III.

**DOUBLE-BEAT VALVES AND
MISCELLANEOUS GEARS.**

PART III.

DOUBLE-BEAT VALVES AND MISCELLANEOUS GEARS.

CONTENTS.—Cornish Valves—Valve Motion for Cornish Valves—Form of Cams—Cornish Valves with Trip Motion—Robey's Valve Gear—Sulzer Valve Gear—Beadle's Valve Gear—Duplex Pump Valve Gear.

The Cornish or Double-Beat Valve has not been extensively adopted in this country, except by makers of large winding and pumping engines; but in a modified form it has for years been largely employed by Continental builders, by whom it has been brought to such perfection that it already compares favourably with the Corliss valve gear. The future practice in steam engines promises to utilise the double-beat valve very largely; for, with the revival of superheating, arises the want of a valve that has no rubbing action on its seat. A similar change took place in the design of gas engine valves some years ago. In the old engines the cycle of operations was controlled by slides, whereas the modern engines have mushroom valves.

Dealing first with the valve proper, the object of the designer should be to produce a mechanism that is as short as possible, light, and has the least possible lift. The common form of Cornish valve is shown by Fig. 122. The narrower the faces or beats the easier is the valve kept tight, but if too narrow they soon become worn and require renewal. The lift necessary to give the full area of the lower seat is (neglecting the wings of the valve)—

$$\frac{1}{2} \left(\frac{D^2}{D + d} \right),$$

where D and d are the diameters of the lower and upper seats respectively. The wings or ribs which are necessary to prevent distortion of the valve under the steam pressure diminish the area, consequently a little more lift is required than is given above, but at the same time the area through the lower seat is considerably diminished by the ribs and the central boss, this should be taken into account from the first, and allowance made, otherwise it may be that the design may be far advanced before the insufficiency of the area is first discovered.

A = width of bar for lower seat.

$B = 2 \text{ lift} + A.$

The area of the annulus C = half the area of lower seat.

Unless the distance between the two faces be made as short as

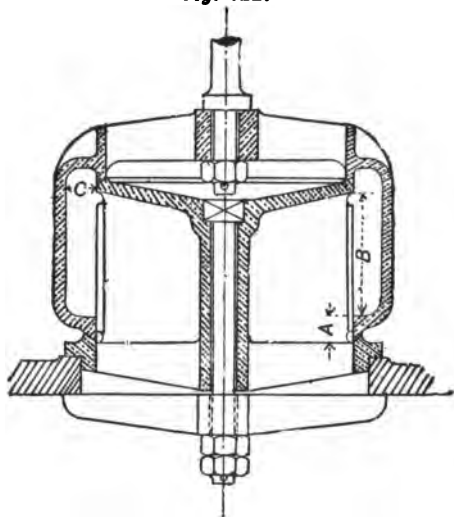
possible, the valve may be leaky, owing to the difference between the expansion of the valve and the seat. The upper seating plate should be well ribbed, or the steam pressure will deflect it, and leakage will ensue; and the valve and seat should be cast of metals having equal coefficients of expansion. With respect to the valve faces the following widths have been found to give satisfaction:—

Valve 6 inches diameter inside largest seat, $\frac{1}{8}$ inch width of seat.

| | | | | | | |
|------|---|---|---|---------------|---|---|
| " 8 | " | " | " | $\frac{1}{8}$ | " | " |
| " 10 | " | " | " | $\frac{1}{8}$ | " | " |
| " 12 | " | " | " | $\frac{1}{8}$ | " | " |
| " 14 | " | " | " | $\frac{1}{8}$ | " | " |

The angle of the faces in each case was 45° , and the width given is measured horizontally, hence the actual width of the seat is $\sqrt{2W^2}$. It will be seen on inspecting the figure that the width

Fig. 122.

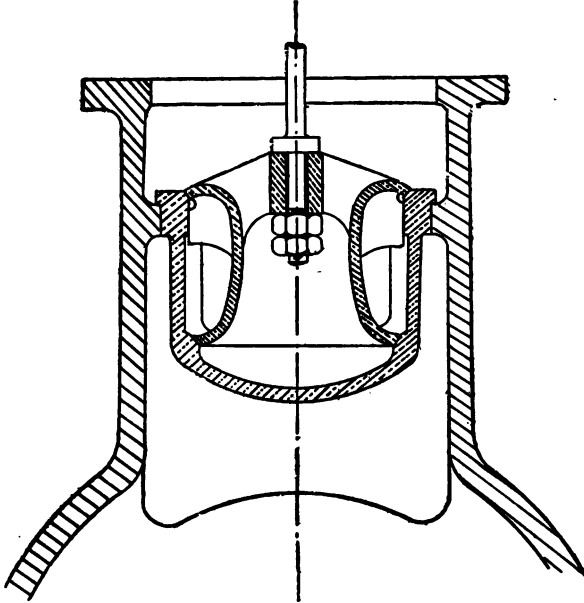


of the faces controls the difference in the diameters of the upper and lower seats, and consequently the power required to lift the valve off the seat. Were the two diameters equal, the valve would be in equilibrium except for its own weight, and the unbalanced area of the spindle, which might counterbalance each other; but unless the valve were under the control of a spring it would be leaky, and the presence of any grit on the faces would seriously impair its working. When the difference between the diameters of the two faces is, however, sufficient to give the widths above mentioned, sufficient unbalanced pressure is brought on the valve to keep it tight, and hammer away the small amount of foreign

matter that might, under the ordinary conditions of working, be deposited on the valve faces.

In the next figure a more modern form of double-beat valve is illustrated. This is an improvement on the previous design, because for a given area the valve is lighter. In all valves of this type it is important that both valve and seat should be of the same metal, so as to avoid difference between the expansion of the two parts, otherwise there will be a continual leakage of steam.

Fig. 128.



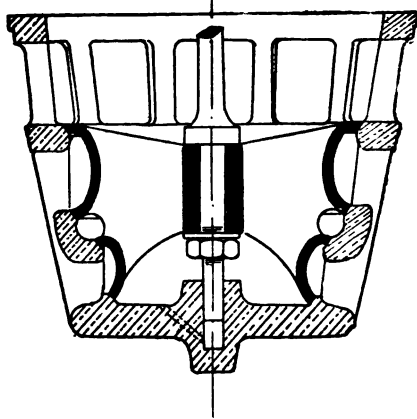
By combining two double-beat valves an extremely small lift for a given area is obtained, a point of some importance in large engines where trip gear is used. Such a valve is shown in the annexed figure. With this type the necessity of attention to equal expansion is emphasised, there being four faces liable to leakage; and first-class workmanship is indispensable to satisfactory working.

A common arrangement of Cornish valve motion is shown in outline in Fig. 125. The position of the cams depends upon the desired point of cut-off. The valves, of course, can have no lap, but by placing the steam cams so that they do not lift the valve until the valve-rod is past its central position the same effect is produced as by a lap on a slide valve. If the levers and cams were set so that when the valve-rod was in the centre of its travel all the valves were just on the point of being lifted or released, the

resulting distribution would be similar to that given by a slide valve having neither steam nor exhaust lap.

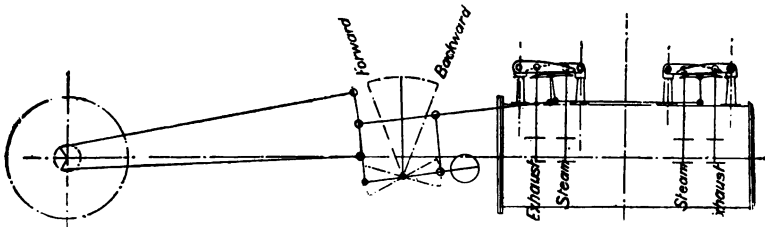
In designing the cams it is important to see that the first point of contact is near the fulcrum of the cam. The advantage of this

Fig. 124.



is twofold. It throws less strain on the valve gear, because at the instant of contact the valve is not in equilibrium. In the second place the speed of the striking part of the cam is slow, and the action, therefore, quiet. When the valve has been lifted it is in equilibrium, and as the point of contact is continually receding from the fulcrum of the cam, the opening is rapid; also, on closing,

Fig. 125.

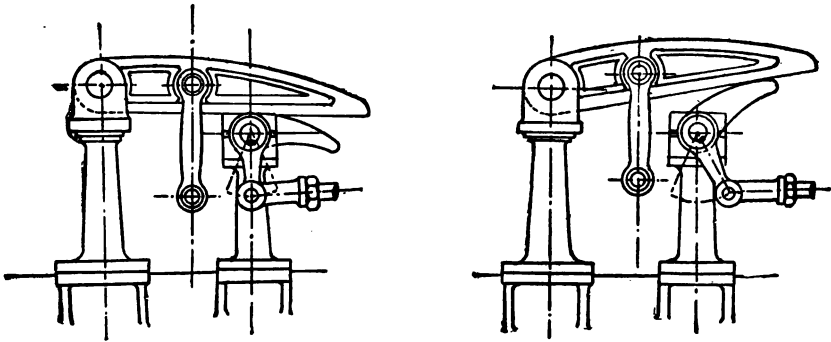


the valve is let down to its seat without a jar. This action will be better understood from Fig. 126, where the cam and lifting lever are shown in two positions, the first in which the valve is on the point of being lifted from its seat, the second in which the valve has attained its extreme lift.

The Cornish valve, when adapted to a tripping arrangement,

forms a useful gear for large winding engines. The essential feature of this class of engine is that it must start rapidly and maintain its speed to the latest possible point in the wind. The gear about to be described accomplishes the desired action in a very effective manner. It was designed by the author in 1898 for a large winding engine in the Lancashire coal-field. In Fig. 127 the valve-rod A and the rocking-rod B receive motion from the eccentrics through the medium of a reversing motion of the straight link type. Until the maximum speed is attained the steam is carried on for nearly the whole length of the stroke, but when the maximum is reached the governor moves the small cams C into a position that brings

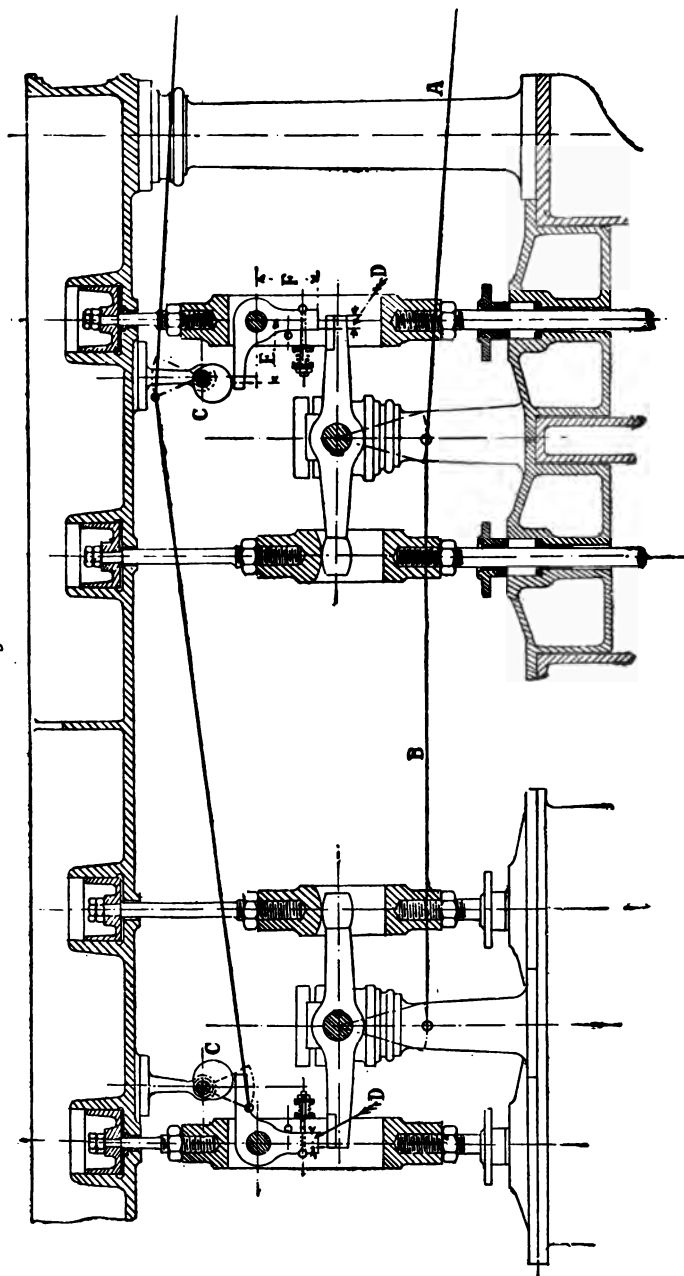
Fig. 126.



them in contact with the rising trip hook. The valve, spindle, stirrup, and hook are then left to fall to the closed position by reason of their weight, and the air cushion, which can be regulated by a small thumb screw, prevents the valve falling violently on its face. In cases where the valve is light and the pressure high, a spring would be necessary to close it promptly, because of the unbalanced area of the valve spindle and the friction of the stuffing box. The maximum speed being once attained, a very small amount of steam is sufficient to maintain it, because the load becomes lighter every instant, owing to the diminishing weight of rope on the ascending cage and the increasing weight on the descending rope. Tripping, of course, must take place before the trip hook begins to descend—that is, somewhat before half-stroke—as in the single eccentric Corliss gear. The indicator diagram from a complete wind will illustrate the action clearly.

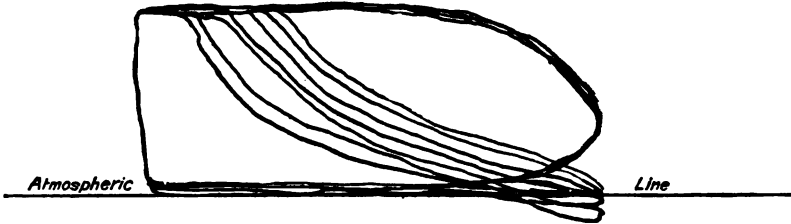
From the figure it appears that after about five revolutions the speed at which tripping occurs is obtained. For several strokes the speed increases, as shown by the early tripping, until, towards the end of the wind, a mere breath is admitted. The stop valve is then closed, the brakes applied, and the engine rapidly brought to rest.

Fig. 127.



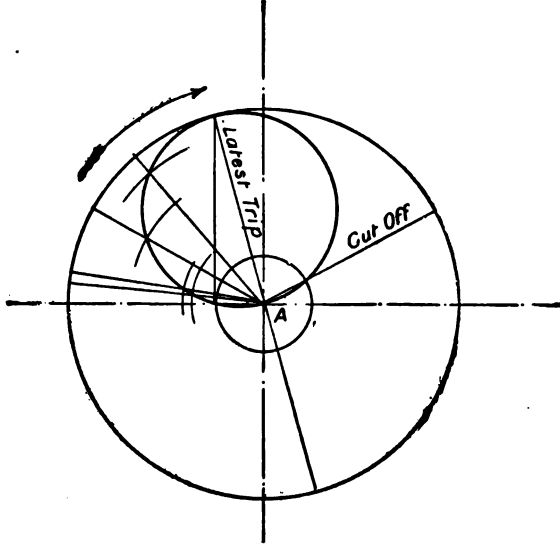
The action of the trip may be clearly shown by means of a Zeuner diagram. In the figure the clearance between the lifting

Fig. 128.



lever and the trip hook is drawn as a lap circle, and the lead being fixed upon the angle of the eccentric is known. Draw the valve circle, and from the centre A, with a radius equal to the distance

Fig. 129.

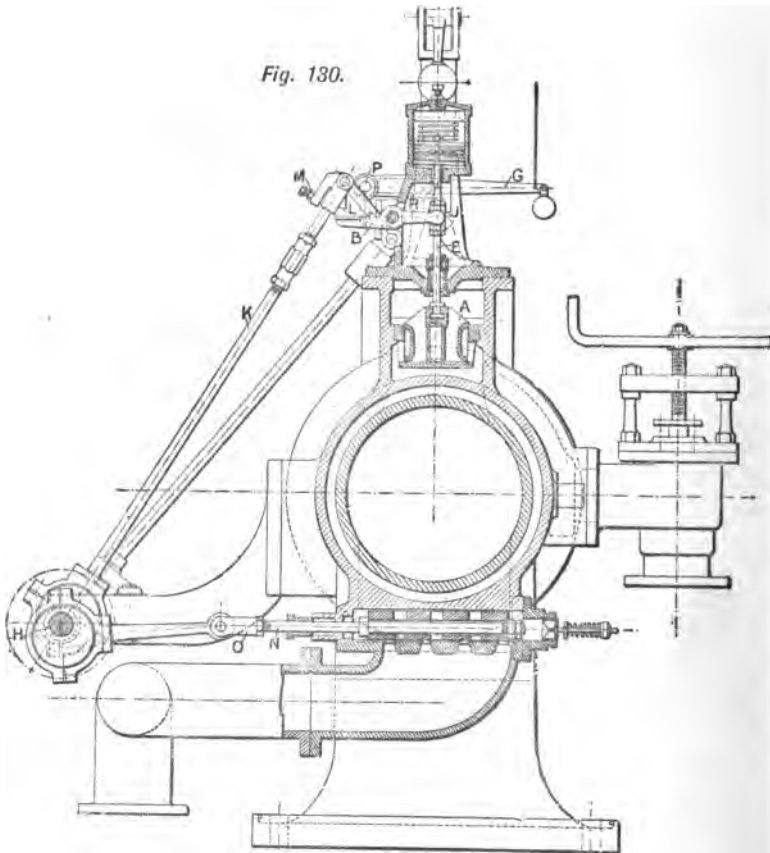


between the pallet of the catch and the cam, + clearance between lifting lever and trip hook, + overlap of tripping edges (D in Fig. 127), describe an arc intersecting the valve circle.* A line drawn

* This construction applies where the distance from the fulcrum of the catch to the point at which the cam strikes is equal to the distance from the fulcrum to the working edge of the catch. Should these be unequal the radius of the arc will be increased or diminished proportionally. In Fig. 127, should the distance E exceed the distance F, the radius of the arc will be greater by the difference of these distances referred to the distance D.

from A through the point of intersection will show the crank position when disengagement takes place. Should the arc fall without the valve circle no disengagement will take place, and steam will be carried on until cut-off occurs by virtue of the clearance of the catches.

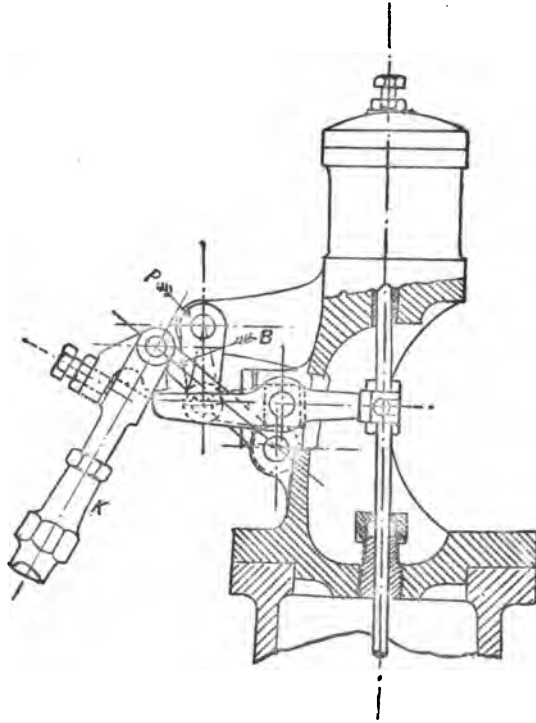
In non-reversing engines the gear for a double-beat valve motion is more conveniently arranged. A horizontal shaft driven by bevel or skew gear is carried parallel to the centre line of the engine. On this shaft the eccentrics are placed at convenient positions. The best known English example of this type of gear is that made by Messrs. Robey & Co., Lincoln. The arrangement will be followed from the accompanying figures. The method of governing



and tripping is similar to that of an ordinary Corliss gear, and the range of tripping depends upon the clearance of the catches and the

lap of same, just as in the Corliss gear the range depends on the ratio of the lap of the valve to its travel. The steam eccentrics are placed at an angle of 180° to each other—that is, opposite. The exhaust valves, it will be noticed, consist of gridiron slides at the bottom of the cylinder. The advantages of this arrangement are the excellent natural drainage of the cylinder and the short travel of the slides. As in the case of the steam valves, the exhaust eccentrics are set opposite to each other. Returning to the detail

Fig. 131

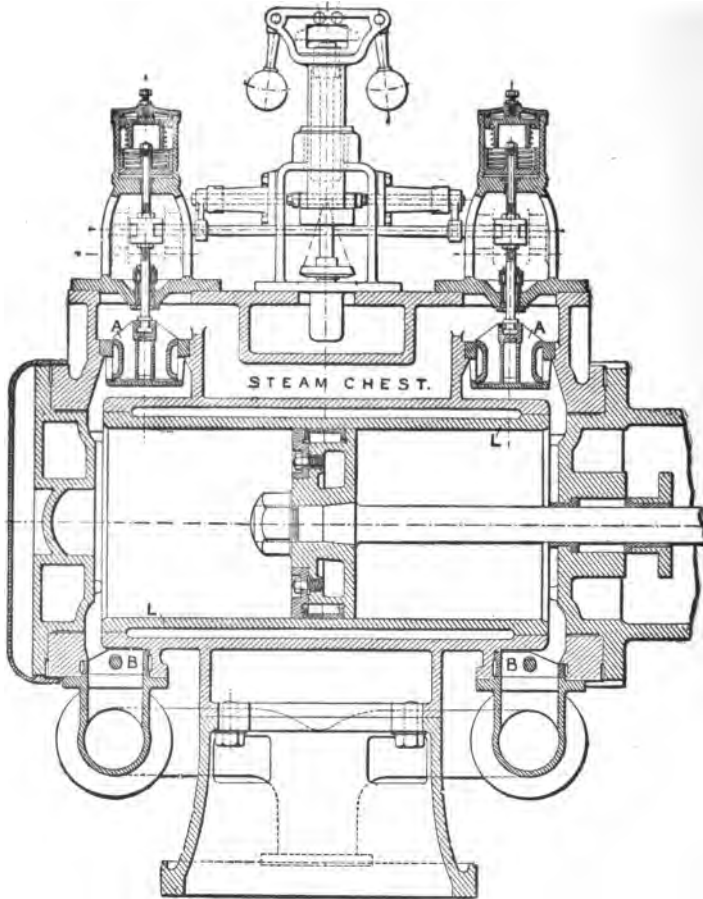


of the trip motion (Fig. 131) the end of the eccentric rod K is carried by the anchor levers B, the fulcras of which are carried by the valve bonnet. As previously stated, the point at which tripping takes place depends on the depth of engagement of the catches, which depth can be adjusted in two ways—permanently by altering the set screw on the catch lever, and temporarily by the action of the governor on the lever P, thus altering the position of the lifting lever. The set screw adjustment is resorted to when

any permanent change in the load is made, or when a permanent increase or decrease of speed is desired; whilst the governor adjusts the cut-off so that the desired speed is uniform.

On setting out the movements of this gear it will be found that a very small movement of the lifting lever will produce a wide

Fig. 132.



variation in the point of cut-off. This means that the mechanical purchase between the balls of the governor and the lever P (Fig. 131) is considerable, consequently the plucking action on the governor is very slight. The lifting lever is forked where it



engages with the valve spindle, and the movable fulcrum is carried in hardened slides, thus permitting the necessary horizontal movement.

The well-known **Sulzer gear** is one of the most interesting examples of drop valve gear, the latest type having several features of great interest. The folding plate illustrates the valve gear on the high-pressure cylinder of the engine exhibited at Paris in 1901. At first sight the gear appears to be unreasonably complicated, but a careful inspection of the figure will show that every part contributes to the efficiency of the gear, and nothing that is wanted in a high-class gear has been forgotten. A general idea of the action will be formed from the plate, but a thorough knowledge of the various movements can only be obtained by drawing down the centre lines and tracing their movements through a complete revolution. Commencing at the lay shaft A, the eccentric-rod B imparts motion to the bell-crank lever C, one of whose arms actuates the exhaust gear, whilst the vertical arm controls the opening of the steam valve. The connection between this arm and the valve-rod D is not of a positive character, however, but arises through the medium of catches E. The fulcrum of the curved lever F G is at P, and as long as the catches are in gear the revolution of the valve shaft in the direction of the arrow will, until the eccentric-rod begins to return, drag down the valve-rod D and lift the steam valve. The fulcrum P also serves as an anchor for the catch lever. This lever likewise receives its motion from an eccentric, and the rod Q connected thereto receives a positive and constant amount, but the position of the motion is altered by the governor operating upon the horizontal shaft H. This portion of the gear resembles the Frikart gear in its action. In the drawing the normal position of the governor lever is shown. As the lever J moves nearer the vertical centre line the release of the catches will be delayed. On the other hand, movement in the opposite direction will accelerate release.

The chief point of interest in this gear, however, lies in the rolling valve levers and adjustable palletts. Referring to the steam rolling lever K, and assuming it to be in its highest position, the first point of contact is close to the end of the lever, which means that the gear has a great leverage over the valves just at the moment the stress comes upon the motion. As soon as the valve is off its seat it is practically in equilibrium, and the rolling lever is then continually decreasing its purchase, thus imparting rapid opening to the valve at the time the piston is travelling at high speed. As to the pallett, it is centred on the pin M, and is adjustable by means of nuts on a thread. The action of the main dashpot will be readily followed, but the supplementary cushion spring is a refinement which Messrs. Sulzer find necessary to give a proper closure to the valve, and its action is peculiar. In the drawing the steam valve is shown full open, but it will be

understood that this is not its correct position in relation to the position of the rest of the gear, but it is so drawn in order to show the extremely short lift of valve. The break in the valve stem indicates that the valve and gear are not drawn in their true positions relative to one another. Returning to the cushion dashpot, it will be observed that when the catches are released the main spring descends with the valve, at the same time lifting the valve rod D, the curved lever, and the cushion dashpot piston. There is no cushioning action on the main spring, but as the cushion piston approaches the end of the cylinder a break is brought upon the main spring, and as this acts at a purchase it is possible to obtain an exceedingly delicate adjustment. Had only the main spring been cushioned some means would have had to be provided for limiting the motion of the rolling lever and the rods in connection with it, otherwise the descent of the main spring would jerk them badly, hence the break cylinders become vital parts of the gear. It is, of course, highly important that the regulation of the closure of the valves should be entirely under control; any hammer on the faces would soon destroy them.

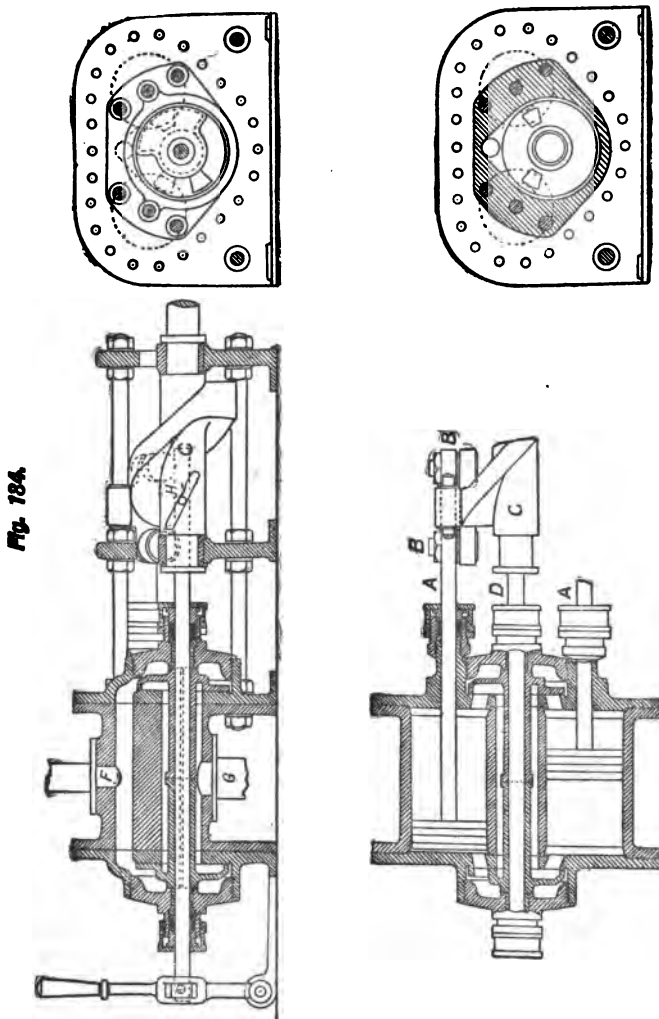
In the exhaust gear the rolling lever and pallet are employed, and the valve is opened against the resistance of a spring, but there is no release gear or cushioning. The valve is shown full open, but that is not its correct position with reference to the rest of the gear.

The plate is well worth close inspection. The very complete arrangements for lubrication are specially interesting, as well as the precautions against waste oil running upon the foundations. The lagging question has also been thoroughly thought out, and accounts in a large measure for the splendid appearance of the Sulzer engines. Another point which is worth notice is the absence of over-hung pins. All levers are jawed where they embrace the rod-ends, or else the rod-ends are jawed and embrace the levers. This renders the manufacture of the moving parts costly, but Messrs. Sulzer ignore expense where efficiency of the gear is concerned.

Beadle's Rotary Valve Gear.—The requirements of an ideal valve gear are perfect equilibrium, unlimited speed, and small clearances. The rotary valve gear made by Mr. O. Hyde Beadle realises to a considerable extent these requirements, and is also very compact. It is most conveniently made with two cylinders, either compound or otherwise, with pistons half a stroke apart, or any other desired position. It will be convenient to illustrate and describe the "helicrank" engine, because it embodies some features which render it of particular value for marine purposes, the cylinders being in axial alignment with the tail shaft.

Referring to the accompanying figures, four views of the helicrank engine are shown—a vertical section through the valve box, a sectional plan through the plane of the piston-rods, and two

end elevations of the engine with the valve chest covers removed. The ends of the piston-rods A are provided with adjustable rollers B, which roll upon the helix C, thereby imparting a rotary motion



to the main shaft, and also to the valve spindle D. The valves consist of two revolving discs with prolonged stems, and suitable slots and cavities to effect the proper distribution. The valves are

mounted on the spindle by means of feather keys, whereby they always rotate with the spindle, but, at the same time, are free end-ways. The faces of the stems are accurately faced, and form the stop which prevents the valves from being forced against their faces. The force tending to press one valve to its face is exactly balanced by the force on the back of the other, and consequently the valves float, rather than rub, upon their face. The steam enters at F, from thence it circulates round the cylinders to the valve chests. The extremely short and direct ports on the cylinder will be noted, and also the absence of external pipes or passages. The exhaust passes round the prolonged stems of the valves, and escapes through G.

The reversal of the rotary valve engines is a very simple matter. One method is that shown in the figure. The valve spindle fits into the helix as shown, and is driven by the peg H. The reversing gear is shown in the mid position, and the action of the valves is such that no rotation would be given to the main shaft, but when the reversing handle is but moved into any other position the effect is to impart axial motion to the valves through the inclined slot in the helicrank. The effect of notching up is almost identical with that of notching up a link motion, only the action is more harmonic.

As showing the easy running of these valves, it may be mentioned that after running six months the valves of one of these engines still exhibited the minute original scratches made by the scraping tool. In ordinary crank engines the valve spindles are driven by mitre or skew gear from the crank shaft in a similar manner to the shaft of a gas engine. Any desired sequence or angle of crank is accommodated by a suitable disposition of the ports leading to the cylinders and the design of the valves themselves.

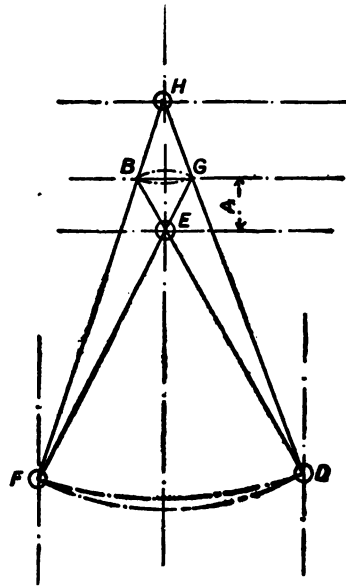
With crank at right angles, or with a helicrank engine with one piston half a stroke in advance of the other, lines joining the centres of the cylinders form a right-angled triangle, and one slot in the valve thus distributes the steam to both cylinders, and one recess controls the exhaust.

Duplex Pump Valve Gear.—Fig. 136 shows a section through one of the steam cylinders of a duplex pump. The general arrangement of this type of pump is well known. There are two distinct and independent cylinders placed opposite and in axial alignment with two pumps, and the piston-rod of each cylinder is coupled directly to the pump-rod. The valve gear of one cylinder is operated from the crosshead of the other. There are two ports in each end of the cylinder, of which the outer ports B are provided for the entering steam, and the inner ports A for the exhaust. When in central position the valve exactly covers the two ports as shown in the illustration. The travel of the valve should not be less than twice the width of one port, and it is often convenient to make it greater. The peculiarity in the connection of the spindle to the valve will be noticed. The nuts are adjusted so that there

is an amount of lost motion between the spindle and the valve, and in arranging the valve levers this must be taken into account. It is impossible, however, to pre-determine the exact amount of this lost motion, hence it is the usual practice to provide for adjustment by an extension of the screwed part of the spindle. Usually the total amount of lost motion varies from $\frac{1}{8}$ inch for pumps with steam cylinders of 4 inches diameter to $\frac{1}{2}$ inch in cylinders 24 inches diameter and upwards. The effect of having too much lost motion is to give a long stroke to the piston, and since there is no mechanical limit to the stroke except that provided by the cylinder covers, the piston may strike. Too little lost motion gives short strokes, which diminishes the delivery of the plungers. As the piston approaches the end of the stroke the inner port is blocked up, and the steam remaining in the cylinder at the front of the advancing piston forms a cushion, which brings it gently to rest. Sometimes cushion valves *EE* are provided, by adjusting which the motion of the piston may be further controlled. From the foregoing it will be understood that the arrangement of the cylinder end must differ from an ordinary cylinder. In the first place, the bell-mouth must not extend past the inner edge of the steam port, otherwise cushioning cannot be efficient, because there would be leakage through to the exhaust port. The ports should also be arranged as shown in the figure, and not recessed into the cover as is common practice in ordinary cylinders, otherwise it will be difficult to obtain proper cushioning, because the piston would strike the covers almost immediately after the inner port was blocked by the piston, and until the port has been covered cushioning cannot begin.

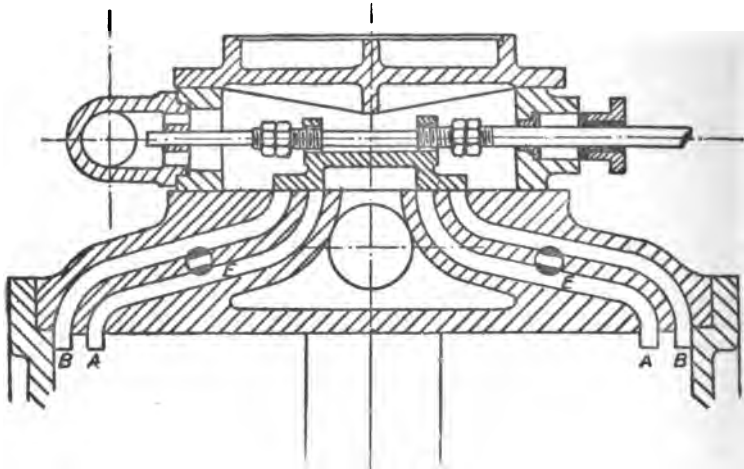
Passing on to the design of the valve levers, each valve has to effect the same travel. The cross-shafts are usually arranged above each other, and, therefore, vary according to the lengths of the levers, but the movement of each extremity must be equal to that of the other, and the proportion or ratio between the valve lever and crosshead lever must be the same in each case. Another point to observe is that the length of the shortest valve lever is sufficient

Fig. 185.



to allow of the connecting link to the valve spindle clearing the cross shaft. Referring to the diagram (Fig. 135), the stroke of the crosshead is from F to D, and is a known quantity. The travel of the valve spindle BG can also be ascertained. The minimum distance A is fixed by the detail of the connecting link and the size of the cross shaft. From B or G draw a line through E cutting the verticals indicating the length of the stroke. The point of intersection indicates the position on the crosshead where the connection to the crosshead lever must be made, and also the length

Fig. 136.



of the lever. Should the position be inconveniently high, a lower point may be selected and the distance A left to find itself. A higher point must not be chosen if A has already been made a minimum. Having determined the proportions of one crosshead and valve lever, draw lines from F or D through B or G, and the point where they intersect the vertical line is the proper centre of the cross shaft. FH or DH is the length of the crosshead lever, and BH or GH the length of the valve lever, and the two valve travels are the same.

Sometimes the lost motion adjustment is outside the steam chest, especially in the case of large sizes. This enables the working of the pumps to be adjusted under steam.

INDEX.

A

ALLAN's gear, Diagram for, 74.
 „ straight link motion, 72.
 Angle of advance, 33.
 „ of vibration, 92.
 „ Reduction of dwelling, 90.
 Application of ellipse diagram, 32.
 Area of ports, 1.
 Arrangement of steam and exhaust valves, 94.
 Automatic expansion gear, 47.
 „ „ Classes of, 43.

B

BALANCED slide valve, 23.
 Beadle's valve gear, 146.
 Bremme's valve gear, 82.
 „ „ applied to vertical marine engines, 83.

C

CAMS, Design of, 138.
 Characteristic line, Method of describing, 59.
 Clearance of catches, 10.
 Comparison of Joy's and Bremme's gear, 84.
 Compression, Percentages of release and, 7, 8.
 Corliss gear, Advantages of, 87.
 „ „ Cla-sification of, 87.
 „ „ Diagram for, 95.
 „ „ Double-ported valve, 99.
 „ equilibrium valve, 100.
 „ exhaust valve, Proportions of, 98.
 „ Popularity of, in America, 111.
 „ valve, Cylinder with, 102.
 „ „ Crank-shaft governors applied to, 101.
 „ „ motion without trip gear, 88.
 „ „ Proportions of, 97, 99.
 Cornish valve, 135.

Crab-claw trip motion, 119.
 Crank-pin diagram, 63.
 „ shaft governor expansion gear, 48.
 Crossed and open rods, 57.

D

DASHPOTS, 124.
 Design of expansion valves, 34.
 Divided slide valve, 9.
 Dobson's trip gear, 120.
 Double bar link with eccentric-rods inside, 65.
 Double bar link with eccentric-rods outside, 66.
 Double-ported Meyer gear, 38.
 „ slide valve, 15, 16.
 Duplex valve gear, 148.
 Dwelling angle, Reduction of, 90.
 „ motion, 90.

E

ECCENTRICS driving obliquely, 69.
 Effect of connecting-rod and equalisation of steam distribution, 11.
 Ellipse diagram, 13, 32, 103.
 Expansion gear, Automatic, 43.
 „ „ crank-shaft governor, 48.
 „ „ Meyer's, 35.
 „ „ regulator, 37.
 „ „ valve, Diagram, 28.
 „ „ Slide, 28.

F

FABOOT cylinder, 131.
 „ trip gear, 129.
 Frikart trip gear, 126.

G

GOOCH's link motion, Crank-pin diagram for, 71.

Gooch's link motion, 67.

" " " " Diagram for, 71.

Goodfellow's trip gear, 123.

Gray's, Macfarlane, method of describing the characteristic line, 59.

H

HACKWORTH's valve gear, 81.

Hartnell's expansion gear diagram, 44.

" governor, 44.

Hick Hargreave's low-pressure gear, 90.

INGLIS & SPENCER slip rod, 118.

" " trip gear, 119.

J

Joy's valve gear, 76.

" " applied to marine engines, 80, 81.

L

LEAD, 2.

Lever, Position of Corliss valve, 93.

Link motion, Allan's straight, 72.

" Gooch's, 67.

" North-Eastern Railway Co., 65.

" Notched up, 60.

" Stephenson's, 56.

Links, Proportions of, 67.

M

MEYER expansion gear, 35.

" gear, Double-ported, 38.

Movement of Corliss valves, 113.

Musgrave's trip gear, 115.

NORTH-EASTERN Railway Co.'s link motion, 64, 65.

O

OPEN and crossed rods, 57.

P

PERCENTAGES of release and compression, 7, 8.

Pins, Valve, 23.

Piston slide valve, Common, 26.

" valve, 24.

Ports, Area of, 1.

Proportions of Corliss exhaust valve, 98.

" " steam valve, 97, 115.

" double-ported Corliss valve, 99.

" links, 67.

R

RADIAL gears, Principle of, 76.

Range of trip, 115.

Release and compression, Percentages of, 7, 8.

Relief rings, 23.

Resultant circles, 29.

Reversing gear, Single eccentric, 52.

Reynolds' trip gear, 108.

" valve diagram for Meyer gear, 42.

" valve diagram for single valve, 41.

Robey's valve gear, 142.

Rotary valve gear, 146.

Ruston Proctor's crab-claw trip gear, 120.

" link expansion gear,

S

SENGLE eccentric reversing gear, 52.

Slide expansion gear, 28.

" " valve diagram, 29.

" valve, Common piston, 26.

" valves, Divided, 9.

Slip curves, 65.

Slot link, 65, 67;

Speed of trip gears, 114.

Spindles, Table of valve, 21, 22.

Steam valve, Proportions of Corliss, 97.

Stephenson's link motion, 56.

Sulzer valve gear, 145.

T

TABLE of valve spindles, 21, 22.

Tandem engines valve gearing, 19.

Templet, Use of, 62.

Thom's trick valve, 17.

Trick valve, 16.

Trip gear, Crab-claw, 119.

Trip gear, Dobson's, 120.
 „ Farcot, 129.
 „ Frikart, 126.
 „ Goodfellow's, 123.
 „ Inglis & Spencer, 118.
 „ Musgrave's, 116.
 „ Principle of, 104.
 „ Reynold's, 104.
 „ „ diagram, 108.
 „ Robey's, 142.
 „ Wheelock, 131.
 Trip levers, Movement of, 109.
 „ motions, 104.

V

VALVE, Balanced, 23.
 „ Common piston slide, 26.
 „ Corliss, Balanced, 100.
 „ „ Double-ported, 98.
 „ „ Exhaust, 98.
 „ „ Steam, 97.
 „ Diagram for Corliss gear, 95.
 „ „ for shifting eccentric gear, 54.

Valve, Diagram for Stephenson's link motion, 57.
 „ „ of slide, 3.
 „ „ of tandem engines, 19.
 „ Double-ported, 15.
 „ gear, Joy's, 76.
 „ Rules for diameter of, 91.
 „ spindles, Table of, 21, 22.
 „ Thom's trick, 17.
 Vibration, Angle of, 92.

W

WESTINGHOUSE governor, 50, 101.
 Wheelock trip gear, 131.
 Winding engine valve gear, 139.
 Wrist plate, Effect of, 89.
 „ pin, Location of, 91.

Z

ZEUNER diagram, Principle of, 4, 30.

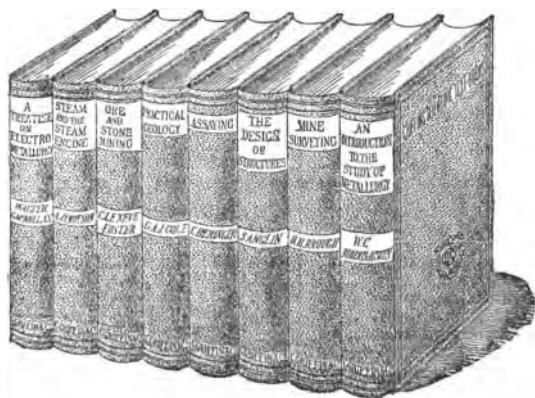


A SELECTION
FROM THE
SCIENTIFIC AND TECHNICAL WORKS

PUBLISHED BY

CHARLES GRIFFIN & COMPANY, LIMITED.

(Being Sections 4-10 from Messrs. Griffin's "General Catalogue.")



MESSRS. CHARLES GRIFFIN & COMPANY'S PUBLICATIONS may be obtained through any Bookseller in the United Kingdom, or will be sent Post-free on receipt of a remittance to cover published price. To prevent delay, Orders should be accompanied by a Cheque or Postal Order crossed "UNION OF LONDON AND SMITH'S BANK, Chancery Lane Branch."

*** For INDEX, see next page.*



COMPLETE TECHNICAL, MEDICAL, and GENERAL CATALOGUES forwarded Post-free on Application.

LONDON:
EXETER STREET, STRAND.

1/1/03.
D.T. 64.

INDEX.

| | PAGE |
|---|------|
| ALLINGHAM (W.), Marine Meteorology, | 41 |
| AITKEN (T.), Road Making, | 79 |
| ANGLIN (S.), Design of Structures, | 36 |
| ARCHBUTT & DEELEY, Lubrication and Lubricants, | 32 |
| BARKER (D. WILSON-), Navigation, | 41 |
| — Seamanship, | 40 |
| BERINGER (J. J. & C.), Assaying, | 66 |
| BILES (Prof. J. H.), Construction of Ships, | 38 |
| BLACKMORE (E.), Mercantile Marine, | 40 |
| BLOUNT (B.) and BLOXAM (A. G.), Chemistry for Engineers, | 47 |
| — Chemistry for Manufacturers, | 71 |
| BLYTH (A. Wynter), Foods and Poisons, | 72 |
| BORCHERS (Dr.), Electric Smelting, | 68 |
| BROUGH (B. H.), Mine-Surveying, | 56 |
| BROWNE (W. R.), Works by, | 47 |
| BRUCE (Robt.), Food Supply, | 55 |
| BUCK (R. C.), Algebra, | 42 |
| — Trigonometry, | 42 |
| BURNS (D.), Colliery Electricity, | 50 |
| BUTTERFIELD (W. J. A.), Gas Manufacture, | 77 |
| CASTELL-EVANS (Prof.), Tables for Chemists, | 79 |
| COLE (Prof. G. A. J.), Practical Geology, | 53 |
| — Open Air Studies in Geology, | 85 |
| COLE (W. H.), Light Railways, | 30 |
| COLLINS (H. F.), Lead and Silver, | 64 |
| COX (S. H.), Prospecting for Minerals, | 55 |
| CRIMP (W. S.), Sewage Disposal Works, | 76 |
| DAVEY (H.), Pumping Machinery, | 37 |
| DIXON (C.), Bird-Life, | 85 |
| DONKIN (Bryan), Gas and Oil Engines, | 28 |
| — Efficiency of Steam Boilers, | 28 |
| DOWSING (H. J.), Electrical Prices, | 38 |
| DUERR (Geo.), Bleaching and Calico-Printing, | 84 |
| DUPRE & HAKE, Manual of Chemistry, | 70 |
| ETHERIDGE (R.), Geology, | 52 |
| FIDLER (Prof.), Bridge-Construction, | 27 |
| FIELD (E. R.), Mining Engineers' Report Book, | 60 |
| FOSTER (Prof. C. le Neve), Ore and Stone Mining, | 56 |
| — Elementary Mining, | 56 |
| GINSBURG (Dr.), Legal Duties of Shipmasters, | 43 |
| GRIFFIN'S Electrical Price-Book, | 38 |
| GURDEN (R.), Traverse Tables, | 33 |
| GUTTMANN (O.), Blasting, | 57 |
| HANNAN (W. I.), Textile Fibres, | 83 |
| HARBORD (F. W.), Steel, | 65 |
| HODGSON (R. B.), Emery Grinding, | 33 |
| HUGHES (H. W.), Coal Mining, | 57 |
| HURST (Chas.), Valves, | 31 |
| — Hints on Engine Design, | 31 |
| HURST (G. H.), Painters' Colours, | 80 |
| — Laboratory Guide to Paints, | 80 |
| — Garment Dyeing and Cleaning, | 84 |
| JAMIESON (Prof.), MANUALS, | 34 |
| — Electrical Tramways, | 34 |
| JENKINS (H. C.), Metallurgical Machinery, | 65 |
| JOHNSON (J. C. F.), Getting Gold, | 59 |
| KASSNER (T.), Gold Seeking, | 60 |
| KERR (G. L.), Practical Coal-Mining, | 58 |
| — Elementary Coal-Mining, | 58 |
| KNECHT & RAWSON, Dyeing, | 82 |
| LAFAR, Technical Mycology, | 73 |

| | PAGE |
|---|--------|
| LAWN (J. G.), Mine Accounts, | 58 |
| LIVERSIDGE (J. G.), Engine-Room Practice, | 29 |
| LYON (Prof.), Building Construction, | 54 |
| MACKENZIE (T.), Mechanics, | 42 |
| M'MILLAN (W. G.), Electro-Metallurgy, | 68 |
| — & BORCHERS, Electric Smelting, | 68 |
| MILL (Dr. R. H.), New Lands, | 54 |
| MILLAR (W. J.), Latitude & Longitude, | 43 |
| MITCHELL (C. A.), Flesh Foods, | 74 |
| MORGAN (J. J.), Metallurgical Analysis, | 67 |
| MUNRO & JAMIESON'S Electrical Pocket-Book, | 49 |
| MUNRO (J. M. H.), Agricultural Analysis, | 75 |
| MUNRO (R. D.), Steam-Boilers, | 32 |
| — Kitchen Boiler Explosions, | 32 |
| NAYLOR (W.), Trades' Waste, | 77 |
| OPPENHEIMER (C.), Ferments, | 74 |
| PARK (J.), Cyanide Process, | 59 |
| PEARCE (W. J.), Painting, | 89 |
| PETTIGREW (W. F.), Locomotive Engineering, | 39 |
| PHILLIPS & BAUERMAN, Metallurgy, | 60 |
| PHIPSON (Dr. T. L.), Earth's Atmosphere, | 53 |
| POYNTING (Prof.), Mean Density, | 50 |
| — & THOMSON, Physics, | 50 |
| PRAEGER (R. L.), Open Air Botany, | 85 |
| RANKINE'S Works, | 35, 36 |
| RAWSON, GARDNER, & LAYCOCK, Dictionary of Dyestuffs, | 82 |
| REDGRAVE (G. R.), Cements, | 76 |
| REDWOOD (Dr. Boverton), Petroleum, | 61 |
| — & THOMSON, Handbook, | 61 |
| — Petroleum Lamp, | 61 |
| REED (Sir E. J.), Stability of Ships, | 39 |
| REID (Geo. M.D.), Sanitation, | 78 |
| RICHHMOND (H. D.), Dairy Chemistry, | 73 |
| ROBERTS-AUSTEN (Prof.), Metallurgy, | 63 |
| — Alloys, | 62 |
| ROBINSON (Prof.), Hydraulics, | 37 |
| ROSE (T. K.), Gold, Metallurgy of, | 63 |
| ROTHWELL (C.F.S.), Textile Printing, | 83 |
| SCHWACKHOFER and BROWNE, Fuel and Water, | 47 |
| SEATON (A. E.), Marine Engineering, | 45 |
| — & ROUTHWAITE, Marine Engineers' Pocket-Book, | 45 |
| SEELEY (Prof.), Physical Geology, | 52 |
| SEXTON (Prof.), Metallurgy, | 66 |
| — Quantitative & Qualitative Analysis, | 79 |
| SHELTON (W. V.), Mechanic's Guide, | 36 |
| SMITH (J.), Shipmaster's Medical Help, | 43 |
| SMITH (Prof. R. H.), Calculus, | 46 |
| — Measurement Conversions, | 46 |
| SYKES (Dr. W. J.), Brewing, | 75 |
| TRAILL (T. W.), Boilers, | 29 |
| TURNER (Thos.), Iron, Metallurgy of, | 65 |
| WALTON (T.), Know Your Own Ship, | 44 |
| — Steel Ships, | 38 |
| WATKINSON (Prof.), Gas Engines, | 29 |
| WEBER (D. O. C.), India Rubber, | 81 |
| WELLS (S. H.), Engineering Drawing, | 26 |
| WIGLEY (T. B.), Goldsmith and Jeweller's Art, | 67 |
| WOOD (Francis), Sanitary Engineering, | 78 |
| WORDINGHAM (C. H.), Central Stations, | 49 |
| WRIGHT (Dr. A.), Oils and Fats, | 81 |
| YEAR-BOOK of Scientific Societies, | 86 |

§§ 4-6. Griffin's Standard Publications

FOR
ENGINEERS, ELECTRICIANS, ARCHITECTS, BUILDERS,
NAVAL, CONSTRUCTORS, AND SURVEYORS.

| | | |
|------------------------------|----------------------------|------------|
| Applied Mechanics, | RANKINE, BROWNE, JAMIESON, | 35, 47, 34 |
| Civil Engineering, | PROF. RANKINE, | 35 |
| Design of Structures, | S. ANGLIN, | 26 |
| Bridge-Construction, | PROF. FIDLER, | 27 |
| Engineering Drawing, | S. H. WELLS, | 26 |
| Road Making, | T. AITKEN, | 79 |
| Sewage Disposal Works, | SANTO CRIMP, | 76 |
| Sanitary Engineering, | F. WOOD, | 78 |
| Traverse Tables, | R. L. GURDEN, | 33 |
| Central Electrical Stations, | C. H. WORDINGHAM, | 49 |
| Light Railways, | W. H. COLE, | 30 |
| Electrical Tramways, | PROF. A. JAMIESON, | 34 |
| Marine Engineering, | A. E. SEATON, | 45 |
| Engine-Room Practice, | J. G. LIVERSIDGE, | 29 |
| Pocket-Book, | SEATON AND ROUNTHWAITE, | 45 |
| Design of Ships, | PROF. HARVARD BILES, | 38 |
| Steel Vessels, | T. WALTON, | 38 |
| Stability of Ships, | SIR E. J. REED, | 38 |
| Nautical Series, | Ed. by CAPT. BLACKMORE, | 39 |
| The Steam-Engine, | RANKINE, JAMIESON, | 35, 34 |
| Locomotive Engineering, | W. F. PETTIGREW, | 30 |
| Valves and Valve-Gearing, | CHAS. HURST, | 31 |
| Hints on Design, | CHAS. HURST, | 31 |
| Pumping Machinery, | H. DAVEY, | 37 |
| Gas, Oil, and Air-Engines, | BRYAN DONKIN, | 28 |
| Gas and Oil Engines, | PROF. WATKINSON, | 29 |
| Boilers: Land and Marine, | T. W. TRAILL, | 29 |
| " Steam, | R. D. MUNRO, | 32 |
| " Kitchen, | R. D. MUNRO, | 32 |
| " Heat Efficiency of, | BRYAN DONKIN, | 28 |
| Chemistry for Engineers, | BLOUNT & BLOXAM, | 47 |
| Fuel and Water, | BROWNE, | 47 |
| Machinery and Millwork, | PROF. RANKINE, | 35 |
| Hydraulic Machinery, | PROF. ROBINSON, | 37 |
| Grinding Machinery, | R. B. HODGSON, | 33 |
| Lubrication and Lubricants, | ARCHBUTT & DEERLEY, | 32 |
| Rules and Tables, | RANKINE AND JAMIESON, | 36 |
| Electrical Pocket-Book, | MUNRO AND JAMIESON, | 49 |
| Electrical Price-Book, | H. J. DOWSING, | 38 |
| The Calculus for Engineers, | PROF. ROBT. H. SMITH, | 46 |
| Measurement Conversions, | PROF. ROBT. H. SMITH, | 46 |

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

THIRD EDITION, Revised, with an Additional Chapter on Foundations.
Numerous Diagrams, Examples, and Tables. Large 8vo. Cloth. 16s.

THE DESIGN OF STRUCTURES:

**A Practical Treatise on the Building of Bridges,
Roofs, &c.**

By S. ANGLIN, C.E.,

Master of Engineering, Royal University of Ireland, late Whitworth Scholar, &c.

"Students of Engineering will find this Text-Book INVALUABLE."—*Architect*.

"The author has certainly succeeded in producing a THOROUGHLY PRACTICAL Text-Book."—*Builder*.

"We can unhesitatingly recommend this work not only to the Student, as the BEST TEXT-BOOK on the subject, but also to the professional engineer as an EXCEEDINGLY VALUABLE book of reference."—*Mechanical World*.

THIRD EDITION. In Two Parts, Published Separately.

A TEXT-BOOK OF

Engineering Drawing and Design

VOL. I.—PRACTICAL GEOMETRY, PLANE, AND SOLID. 3s.

VOL. II.—MACHINE AND ENGINE DRAWING AND DESIGN. 4s. 6d.

BY

SIDNEY H. WELLS, WH.Sc.,

A.M.INST.C.E., A.M.INST.MECH.E.,

Principal of the Battersea Polytechnic Institute, and Head of the Engineering Department therein; formerly of the Engineering Departments of the Yorkshire College, Leeds; and Dulwich College, London.

With many Illustrations, specially prepared for the Work, and numerous Examples, for the Use of Students in Technical Schools and Colleges.

"A THOROUGHLY USEFUL WORK, exceedingly well written. For the many Examples and Questions we have nothing but praise."—*Nature*.

"A CAPITAL TEXT-BOOK, arranged on an EXCELLENT SYSTEM, calculated to give an intelligent grasp of the subject, and not the mere faculty of mechanical copying. . . . Mr. Wells shows how to make COMPLETE WORKING-DRAWINGS, discussing fully each step in the design."—*Electrical Review*

"The first book leads EASILY and NATURALLY towards the second, where the technical pupil brought into contact with large and more complex designs."—*The Schoolmaster*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

THIRD EDITION, *Thoroughly Revised. Royal 8vo. With numerous Illustrations and 13 Lithographic Plates. Handsome Cloth. Price 30s.*

A PRACTICAL TREATISE ON BRIDGE-CONSTRUCTION:

Being a Text-Book on the Construction of Bridges in
Iron and Steel.

FOR THE USE OF STUDENTS, DRAUGHTSMEN, AND ENGINEERS.

BY T. CLAXTON FIDLER, M. INST. C. E.,
Prof. of Engineering, University College, Dundee.

GENERAL CONTENTS.

PART I.—ELEMENTARY STATICS:—Definitions—The Opposition and Balance of Forces—Bending Strain—The Graphic Representation of Bending Moments.

PART II.—GENERAL PRINCIPLES OF BRIDGE-CONSTRUCTION:—The Comparative Anatomy of Bridges—Combined or Composite Bridges—Theoretical Weight of Bridges—On Deflection, or the Curve of a Bended Girder—Continuous Girders.

PART III.—THE STRENGTH OF MATERIALS:—Theoretical Strength of Columns—Design and Construction of Struts—Strength and Construction of Ties—Working Strength of Iron and Steel, and the Working Stress in Bridges—Wöhler's Experiments.

PART IV.—THE DESIGN OF BRIDGES IN DETAIL:—The Load on Bridges—Calculation of Stresses due to the Movable Load—Parallel Girders—Direct Calculation of the Weight of Metal—Parabolic Girders, Polygonal Trusses, and Curved Girders—Suspension Bridges and Arches: Flexible Construction—Rigid Construction—Bowstring Girders used as Arches or as Suspension Bridges—Rigid Arched Ribs or Suspension Ribs—Continuous Girders and Cantilever Bridges—The Niagara Bridge—The Forth Bridge—Wind-Pressure and Wind-Bracing: Modern Experiments.

"The new edition of Mr. Fidler's work will again occupy the same CONSPICUOUS POSITION among professional text-books and treatises as has been accorded to its predecessors. The instruction imparted is SOUND, SIMPLE, AND FULL. The volume will be found valuable and useful alike to those who may wish to study only the theoretical principles enunciated, and . . . to others whose object and business is . . . practical."—*The Engineer*.

"MR. FIDLER'S SUCCESS arises from the combination of EXPERIENCE and SIMPLICITY OF TREATMENT displayed on every page. . . . Theory is kept in subordination to Practice, and his book is, therefore, as useful to girder-makers as to students of Bridge Construction."—*The Architect*.

"AN INDISPENSABLE HANDBOOK for the practical Engineer."—*Nature*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

Works by BRYAN DONKIN, M.Inst.C.E., M.Inst.Mech.E., &c.

THIRD EDITION, Revised and Enlarged. With additional Illustrations. Large 8vo, Handsome Cloth. 25s.

GAS, OIL, AND AIR ENGINES:

A Practical Text-Book on Internal Combustion Motors without Boiler.

By BRYAN DONKIN, M.Inst.C.E., M.Inst.Mech.E.

GENERAL CONTENTS.—Gas Engines:—General Description—History and Development—British, French, and German Gas Engines—Gas Production for Motive Power—Theory of the Gas Engine—Chemical Composition of Gas in Gas Engines—Utilisation of Heat—Explosion and Combustion. Oil Motors:—History and Development—Various Types—Pierston's and other Oil Engines. Hot-Air Engines:—History and Development—Various Types: Stirling's, Ericsson's, &c., &c.

"The BEST BOOK NOW PUBLISHED on Gas, Oil, and Air Engines. . . . Will be of VERY GREAT INTEREST to the numerous practical engineers who have to make themselves familiar with the motor of the day. . . . Mr. Donkin has the advantage of LONG PRACTICAL EXPERIENCE, combined with HIGH SCIENTIFIC AND EXPERIMENTAL KNOWLEDGE, and an accurate perception of the requirements of Engineers."—*The Engineer*.

"We HEARTILY RECOMMEND Mr. Donkin's work. . . . A monument of careful labour. . . . Luminous and comprehensive."—*Journal of Gas Lighting*.

"A thoroughly RELIABLE and EXHAUSTIVE Treatise."—*Engineering*.

In Quarto, Handsome Cloth. With Numerous Plates. 25s.

THE HEAT EFFICIENCY OF STEAM BOILERS (LAND, MARINE, AND LOCOMOTIVE).

With many Tests and Experiments on different Types of Boilers, as to the Heating Value of Fuels, &c., with Analyses of Gases and Amount of Evaporation, and Suggestions for the Testing of Boilers.

By BRYAN DONKIN, M.Inst.C.E.

GENERAL CONTENTS.—Classification of different Types of Boilers—425 Experiments on English and Foreign Boilers with their Heat Efficiencies shown in Fifty Tables—Fire Grates of Various Types—Mechanical Stokers—Combustion of Fuel in Boilers—Transmission of Heat through Boiler Plates, and their Temperature—Feed Water Heaters, Superheaters, Feed Pumps, &c.—Smoke and its Prevention—Instruments used in Testing Boilers—Marine and Locomotive Boilers—Fuel Testing Stations—Discussion of the Trials and Conclusions—On the Choice of a Boiler, and Testing of Land, Marine, and Locomotive Boilers—Appendices—Bibliography—Index.

With Plates illustrating Progress made during recent years, and the best Modern Practice.

"A WORK OF REFERENCE AT PRESENT UNIQUE. Will give an answer to almost any question connected with the performance of boilers that it is possible to ask."—*Engineer*.

"Probably the MOST EXHAUSTIVE résumé that has ever been collected. A PRACTICAL BOOK by a thoroughly practical man."—*Iron and Coal Trades Review*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

THIRD EDITION, Revised and Enlarged. Pocket-Size, Leather, 12s. 6d.; also Larger Size for Office Use, Cloth, 12s. 6d.

Boilers, Marine and Land:

THEIR CONSTRUCTION AND STRENGTH.

A HANDBOOK OF RULES, FORMULÆ, TABLES, &c., RELATIVE TO MATERIAL, SCANTLINGS, AND PRESSURES, SAFETY VALVES, SPRINGS, FITTINGS AND MOUNTINGS, &c.

FOR THE USE OF ENGINEERS, SURVEYORS, BOILER-MAKERS, AND STEAM USERS.

By T. W. TRAILL, M. INST. C.E., F.E.R.N.,

Late Engineer Surveyor-in-Chief to the Board of Trade.

* * To THE SECOND AND THIRD EDITIONS MANY NEW TABLES for PRESSURE, up to 200 LBS. per SQUARE INCH have been added.

"THE MOST VALUABLE WORK on Boilers published in England."—*Shipping World*.

Contains an ENORMOUS QUANTITY OF INFORMATION arranged in a very convenient form. . . .
A MOST USEFUL VOLUME . . . supplying information to be had nowhere else."—*The Engineer*.

Third Impression. Large Crown 8vo. With numerous Illustrations. 6s.

ENGINE-ROOM PRACTICE:

A Handbook for Engineers and Officers in the Royal Navy and Mercantile Marine, Including the Management of the Main and Auxiliary Engines on Board Ship.

By JOHN G. LIVERSIDGE,

Engineer, R.N., A.M.I.C.E., Instructor in Applied Mechanics at the Royal Naval College, Greenwich.

Contents.—General Description of Marine Machinery.—The Conditions of Service and Duties of Engineers of the Royal Navy.—Entry and Conditions of Service of Engineers of the Leading S.S. Companies.—Raising Steam.—Duties of a Steaming Watch on Engines and Boilers.—Shutting off Steam.—Harbour Duties and Watches.—Adjustments and Repairs of Engines.—Preservation and Repairs of "Tank" Boilers.—The Hull and its Fittings.—Cleaning and Painting Machinery.—Reciprocating Pumps, Feed Heaters, and Automatic Feed-Water Regulators.—Evaporators.—Steam Boats.—Electric Light Machinery.—Hydraulic Machinery.—Air-Compressing Pumps.—Refrigerating Machines.—Machinery of Destroyers.—The Management of Water-Tube Boilers.—Regulations for Entry of Assistant Engineers, R.N.—Questions given in Examinations for Promotion of Engineers, R.N.—Regulations respecting Board of Trade Examinations for Engineers, &c.

"The contents CAN NOT FAIL TO BE APPRECIATED."—*The Steamship*.
"This VERY USEFUL BOOK. . . . ILLUSTRATIONS are of GREAT IMPORTANCE in a work of this kind, and it is satisfactory to find that SPECIAL ATTENTION has been given in this respect."—*Engineers' Gazette*.

In Crown 8vo, extra, with Numerous Illustrations. [Shortly.]

GAS AND OIL ENGINES:

An Introductory Text-Book on the Theory, Design, Construction, and Testing of Internal Combustion Engines without Boiler.

FOR THE USE OF STUDENTS.

By PROF. W. H. WATKINSON, WHIT. SCH., M. INST. MECH. E.,
Glasgow and West of Scotland Technical College.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

SECOND EDITION, Revised. With numerous Plates reduced from Working Drawings and 280 Illustrations in the Text. 21s.

A MANUAL OF LOCOMOTIVE ENGINEERING:

A Practical Text-Book for the Use of Engine Builders,
Designers and Draughtsmen, Railway
Engineers, and Students.

BY

WILLIAM FRANK PETTIGREW, M.INST.C.E.

With a Section on American and Continental Engines.

By ALBERT F. RAVENSHEAR, B.Sc.,

Of His Majesty's Patent Office.

Contents.—Historical Introduction, 1763-1863.—Modern Locomotives: Simple.—Modern Locomotives: Compound.—Primary Consideration in Locomotive Design.—Cylinders, Steam Chests, and Stuffing Boxes.—Pistons, Piston Rods, Crossheads, and Slide Bars.—Connecting and Coupling Rods.—Wheels and Axles, Axle Boxes, Hornblocks, and Bearing Springs.—Balancing.—Valve Gear.—Slide Valves and Valve Gear Details.—Tramming, Engines and Axle Trucks, Radial Axle Boxes.—Boilers.—Smokebox, Blast Pipe, Firebox Fittings.—Boiler Mountings.—Tenders.—Railway Brakes.—Lubrication.—Consumption of Fuel, Evaporation and Engine Efficiency.—American Locomotives.—Continental Locomotives.—Repairs, Running, Inspection, and Renewals.—Three Appendices.—Index.

"Likely to remain for many years the STANDARD WORK for those wishing to learn Design."—*Engineer*.

"A most interesting and valuable addition to the bibliography of the Locomotive."—*Railway Official Gazette*.

"We recommend the book as THOROUGHLY PRACTICAL in its character, and MERITING A PLACE in ANY COLLECTION of . . . works on Locomotive Engineering."—*Railway News*.

"The work CONTAINS ALL THAT CAN BE LEARNED from a book upon such a subject. It will at once rank as THE STANDARD WORK UPON THIS IMPORTANT SUBJECT."—*Railway Magazine*.

In Large 8vo. Handsome Cloth. With Plates and Illustrations. 16s.

LIGHT RAILWAYS AT HOME AND ABROAD.

By WILLIAM HENRY COLE, M.INST.C.E.,

Late Deputy-Manager, North-Western Railway, India.

Contents.—Discussion of the Term "Light Railways."—English Railways, Rates, and Farmers.—Light Railways in Belgium, France, Italy, other European Countries, America and the Colonies, India, Ireland.—Road Transport as an alternative.—The Light Railways Act, 1896.—The Question of Gauge.—Construction and Working.—Locomotives and Rolling-Stock.—Light Railways in England, Scotland, and Wales.—Appendices and Index.

"Mr. W. H. Cole has brought together . . . a LARGE AMOUNT OF VALUABLE INFORMATION . . . hitherto practically inaccessible to the ordinary reader."—*Times*.

"Will remain, for some time yet, a STANDARD WORK in everything relating to Light Railways."—*Engineer*.

"The author has extended practical experience that makes the book lucid and useful. It is EXCEEDINGLY well done."—*Engineering*.

"The whole subject is EXHAUSTIVELY and PRACTICALLY considered. The work can be cordially recommended as INDISPENSABLE to those whose duty it is to become acquainted with one of the prime necessities of the immediate future."—*Railway Official Gazette*.

"THERE COULD BE NO BETTER BOOK of first reference on its subject. All classes of Engineers will welcome its appearance."—*Scotsman*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

THIRD EDITION, Revised and Enlarged. *With Numerous Illustrations. Price 8s. 6d.*

VALVES AND VALVE-GEARING:

INCLUDING THE CORLISS VALVE AND TRIP GEARS.

BY

CHARLES HURST, Practical Draughtsman.

"CONCISE explanations illustrated by 115 VERY CLEAR DIAGRAMS and drawings and 4 folding-plates . . . the book fulfils a VALUABLE function."—*Athenæum*.

"MR. HURST'S VALVES and VALVE-GEARING will prove a very valuable aid, and tend to the production of Engines of scientific design and economical working. . . . Will be largely sought after by Students and Designers."—*Marine Engineer*.

"USEFUL and THOROUGHLY PRACTICAL. Will undoubtedly be found of GREAT VALUE to all concerned with the design of Valve-gearing."—*Mechanical World*.

"ALMOST EVERY TYPE of VALVE and its gearing is clearly set forth, and illustrated in such a way as to be READILY UNDERSTOOD and PRACTICALLY APPLIED by either the Engineer, Draughtsman, or Student. . . . Should prove both USEFUL and VALUABLE to all Engineers seeking for RELIABLE and CLEAR information on the subject. Its moderate price brings it within the reach of all."—*Industries and Iron*.

"MR. HURST'S work is ADMIRABLY suited to the needs of the practical mechanic. . . . It is free from any elaborate theoretical discussions, and the explanations of the various types of valve-gear are accompanied by diagrams which render them EASILY UNDERSTOOD."—*The Scientific American*.

In Paper Boards, 8vo., Cloth Back. Price 1s. 6d. net.

HINTS ON

Steam Engine Design and Construction.

BY

CHARLES HURST.

AUTHOR OF "VALVES AND VALVE-GEARING."

WITH NUMEROUS ILLUSTRATIONS.

CONTENTS.

| | |
|-------------------------------|---------------------------------|
| I. Steam Pipes. | VI. Crank Shafts and Pedestals. |
| II. Valves. | VII. Valve Gear. |
| III. Cylinders. | VIII. Lubrication. |
| IV. Air Pumps and Condensers. | IX. Miscellaneous Details. |
| V. Motion Work. | INDEX. |

"A handy volume which every practical young engineer should possess."—*The Model Engineer*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

Large 8vo, Handsome Cloth. With Illustrations, Tables, &c. 21s.

Lubrication & Lubricants:

A TREATISE ON THE THEORY AND PRACTICE OF LUBRICATION

AND ON THE

NATURE, PROPERTIES, AND TESTING OF LUBRICANTS.

By LEONARD ARCHBUTT, F.I.C., F.O.S.,
Chemist to the Midland Railway Company,

AND

R. MOUNTFORD DEELEY, M.I.M.E., F.G.S.,
Midland Railway Locomotive Works' Manager, Derby.

CONTENTS.—I. Friction of Solids.—II. Liquid Friction or Viscosity, and Plastic Friction.—III. Superficial Tension.—IV. The Theory of Lubrication.—V. Lubricants, their Sources, Preparation, and Properties.—VI. Physical Properties and Methods of Examination of Lubricants.—VII. Chemical Properties and Methods of Examination of Lubricants.—VIII. The Systematic Testing of Lubricants by Physical and Chemical Methods.—IX. The Mechanical Testing of Lubricants.—X. The Design and Lubrication of Bearings.—XI. The Lubrication of Machinery.—INDEX.

"Destined to become a CLASSIC on the subject."—*Industries and Iron.*

"Contains practically ALL THAT IS KNOWN on the subject. Deserves the careful attention of all Engineers."—*Railway Official Guide.*

FOURTH EDITION. *Very fully Illustrated. Cloth, 4s. 6d.*

STEAM - BOILERS:

THEIR DEFECTS, MANAGEMENT, AND CONSTRUCTION.

By R. D. MUNRO,

Chief Engineer of the Scottish Boiler Insurance and Engine Inspection Company.

GENERAL CONTENTS.—I. EXPLOSIONS caused (1) by Overheating of Plates—(2) By Defective and Overloaded Safety Valves—(3) By Corrosion, Internal or External—(4) By Defective Design and Construction (Unsupported Flue Tubes; Unstrengthened Manholes; Defective Staying; Strength of Rivetted Joints; Factor of Safety)—II. CONSTRUCTION OF VERTICAL BOILERS: Shells—Crown Plates and Uptake Tubes—Man-Holes, Mud-Holes, and Fire-Holes—Fireboxes—Mountings—Management—Cleaning—Table of Bursting Pressures of Steel Boilers—Table of Rivetted Joints—Specifications and Drawings of Lancashire Boiler for Working Pressures (a) 80 lbs.; (b) 200 lbs. per square inch respectively.

"A valuable companion for workmen and engineers engaged about Steam Boilers, ought to be carefully studied, and ALWAYS AT HAND."—*Coll. Guardian.*

"The book is VERY USEFUL, especially to steam users, artisans, and young Engineers."—*Engineer.*

BY THE SAME AUTHOR.

KITCHEN BOILER EXPLOSIONS: Why

they Occur, and How to Prevent their Occurrence. A Practical Handbook based on Actual Experiment. With Diagram and Coloured Plate. Price 3s.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

JUST OUT. *In Crown 8vo, Handsome Cloth. With Numerous Illustrations.*

EMERY GRINDING MACHINERY.

A Text-Book of Workshop Practice in General Tool Grinding, and the Design, Construction, and Application of the Machines Employed.

BY

R. B. HODGSON, A.M. INST. MECH. E.,

Author of "Machines and Tools Employed in the Working of Sheet Metals."

INTRODUCTION.—Tool Grinding.—Emery Wheels.—Mounting Emery Wheels.—Emery Rings and Cylinders.—Conditions to Ensure Efficient Working.—Leading Types of Machines.—Concave and Convex Grinding.—Cup and Cone Machines.—Multiple Grinding.—"Guest" Universal and Cutter Grinding Machines.—Ward Universal Cutter Grinder.—Press.—Tool Grinding.—Lathe Centre Grinder.—Polishing.—INDEX.

FIFTH EDITION. Folio, strongly half-bound, 21/.

TRAVERSE TABLES:

Computed to Four Places of Decimals for every Minute of Angle up to 100 of Distance.

For the use of Surveyors and Engineers.

BY

RICHARD LLOYD GURDEN,

Authorised Surveyor for the Governments of New South Wales and Victoria.

* * Published with the Concurrence of the Surveyors-General for New South Wales and Victoria.

"Those who have experience in exact SURVEY-WORK will best know how to appreciate the enormous amount of labour represented by this valuable book. The computations enable the user to ascertain the sines and cosines for a distance of twelve miles to within half an inch, and this BY REFERENCE TO BUT ONE TABLE, in place of the usual Fifteen minute computations required. This alone is evidence of the assistance which the Tables ensure to every user, and as every Surveyor in active practice has felt the want of such assistance FEW KNOWING OF THEIR PUBLICATION WILL REMAIN WITHOUT THEM."

—*Engineer.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

WORKS BY

ANDREW JAMIESON, M.INST.C.E., M.I.E.E., F.R.S.E.,*Formerly Professor of Electrical Engineering, The Glasgow and West of Scotland Technical College.***PROFESSOR JAMIESON'S ADVANCED TEXT-BOOKS.***In Large Crown 8vo. Fully Illustrated.***STEAM AND STEAM-ENGINES (A Text-Book on),**

For the Use of Students preparing for Competitive Examinations. With 600 pp., over 200 Illustrations, 6 Folding Plates, and numerous Examination Papers. THIRTEENTH EDITION, Revised. 8/6.

"Professor Jamieson fascinates the reader by his CLEARNESS OF CONCEPTION AND SIMPLICITY OF EXPRESSION. His treatment recalls the lecturing of Faraday."—*Athenaeum*."The BEST BOOK yet published for the use of Students."—*Engineer*.**MAGNETISM AND ELECTRICITY (An Advanced Text-**

Book on). For Advanced and "Honours" Students. By Prof. Jamieson, assisted by David Robertson, B.Sc., Professor of Electrical Engineering in the Merchant Venturers' Technical College, Bristol. [Shortly.]

APPLIED MECHANICS (An Advanced Text-Book on).

Vol. I.—Comprising Part I.: The Principle of Work and its applications; Part II.: Gearing. Price 7s. 6d. THIRD EDITION.

"FULLY MAINTAINS the reputation of the Author."—*Pract. Engineer*.

Vol. II.—Comprising Parts III. to VI.: Motion and Energy; Graphic Statics; Strength of Materials; Hydraulics and Hydraulic Machinery. SECOND EDITION. 8s. 6d.

"WELL AND LUCIDLY WRITTEN."—*The Engineer*.

* * Each of the above volumes is complete in itself, and sold separately.

PROFESSOR JAMIESON'S INTRODUCTORY MANUALS.*Crown 8vo. With Illustrations and Examination Papers.***STEAM AND THE STEAM-ENGINE (Elementary**

Manual of). For First-Year Students. NINTH EDITION, Revised. 3/6.

"Should be in the hands of EVERY engineering apprentice."—*Practical Engineer*.**MAGNETISM AND ELECTRICITY (Elementary Manual**

of). For First-Year Students. FIFTH EDITION. 3/6.

"A CAPITAL TEXT-BOOK . . . The diagrams are an important feature."—*Schoolmaster*."A THOROUGHLY TRUSTWORTHY Text-book. PRACTICAL and clear."—*Nature*.**APPLIED MECHANICS (Elementary Manual of).**

Specially arranged for First-Year Students. FIFTH EDITION, Revised. 3/6.

"The work has VERY HIGH QUALITIES, which may be condensed into the one word 'CLEAR.'"—*Science and Art*.*IN PREPARATION. 300 pages. Crown 8vo. Profusely Illustrated.***MODERN ELECTRIC TRAMWAY TRACTION :***A Text-Book of Present-Day Practice.**For the Use of Electrical Engineering Students and those interested in Electric Transmission of Power.*

BY PROF. ANDREW JAMIESON.

A POCKET-BOOK of ELECTRICAL RULES and TABLES.

For the Use of Electricians and Engineers. Pocket Size. Leather, 8s. 6d. SIXTEENTH EDITION. [See p. 49.]

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

WORKS BY

W. J. MACQUORN RANKINE, LL.D., F.R.S.,

Late Regius Professor of Civil Engineering in the University of Glasgow.

THOROUGHLY REVISED BY

W. J. MILLAR, C.E.,

Late Secretary to the Institute of Engineers and Shipbuilders in Scotland.

A MANUAL OF APPLIED MECHANICS :

Comprising the Principles of Statics and Cinematics, and Theory of Structures, Mechanism, and Machines. With Numerous Diagrams.
Crown 8vo, cloth. **SIXTEENTH EDITION.** 12s. 6d.

A MANUAL OF CIVIL ENGINEERING :

Comprising Engineering Surveys, Earthwork, Foundations, Masonry, Carpentry, Metal Work, Roads, Railways, Canals, Rivers, Waterworks, Harbours, &c. With Numerous Tables and Illustrations. Crown 8vo cloth. **TWENTY-FIRST EDITION.** 16s.

A MANUAL OF MACHINERY AND MILLWORK :

Comprising the Geometry, Motions, Work, Strength, Construction, and Objects of Machines, &c. Illustrated with nearly 300 Woodcuts. Crown 8vo, cloth. **SEVENTH EDITION.** 12s. 6d.

**A MANUAL OF THE STEAM-ENGINE AND OTHER
PRIME MOVERS :**

With a Section on GAS, OIL, and AIR ENGINES, by BRYAN DONKIN, M.Inst.C.E. With Folding Plates and Numerous Illustrations. Crown 8vo, cloth. **FIFTEENTH EDITION.** 12s. 6d.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

PROF. RANKINE'S WORKS—(*Continued*).

USEFUL RULES AND TABLES:

For Architects, Builders, Engineers, Founders, Mechanics, Shipbuilders, Surveyors, &c. With APPENDIX for the use of ELECTRICAL ENGINEERS. By Professor JAMIESON, F.R.S.E. SEVENTH EDITION. 10s. 6d.

A MECHANICAL TEXT-BOOK:

A Practical and Simple Introduction to the Study of Mechanics. By Professor RANKINE and E. F. RAMBER, C.E. With Numerous Illustrations. Crown 8vo, cloth. FIFTH EDITION. 9s.

*. * THE "MECHANICAL TEXT-BOOK" was designed by Professor RANKINE as an INTRODUCTION to the above Series of Manuals.

MISCELLANEOUS SCIENTIFIC PAPERS.

Royal 8vo. Cloth, 31s. 6d.

Part I. Papers relating to Temperature, Elasticity, and Expansion of Vapours, Liquids, and Solids. Part II. Papers on Energy and its Transformations. Part III. Papers on Wave-Forms, Propulsion of Vessels, &c.

With Memoir by Professor TAIT, M.A. Edited by W. J. MILLAR, C.E. With fine Portrait on Steel, Plates, and Diagrams.

"No more enduring Memorial of Professor Rankine could be devised than the publication of these papers in an accessible form. . . . The Collection is most valuable on account of the nature of his discoveries, and the beauty and completeness of his analysis. . . . The Volume exceeds in importance any work in the same department published in our time."—*Architect*.

SHELTON-BEY (W. Vincent, Foreman to the Imperial Ottoman Gun Factories, Constantinople):

THE MECHANIC'S GUIDE: A Hand-Book for Engineers and Artisans. With Copious Tables and Valuable Recipes for Practical Use. Illustrated. *Second Edition.* Crown 8vo. Cloth, 7/6.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

In Large 8vo, Handsome Cloth. With Frontispiece, several Plates, and over 250 Illustrations. 21s.

THE PRINCIPLES AND CONSTRUCTION OF PUMPING MACHINERY (STEAM AND WATER PRESSURE).

With Practical Illustrations of ENGINES and PUMPS applied to MINING,
TOWN WATER SUPPLY, DRAINAGE of Lands, &c., also Economy
and Efficiency Trials of Pumping Machinery.

BY HENRY DAVEY,

Member of the Institution of Civil Engineers, Member of the Institution of
Mechanical Engineers, F.G.S., &c.

CONTENTS—Early History of Pumping Engines—Steam Pumping Engines—Pumps and Pump Valves—General Principles of Non-Rotative Pumping Engines—The Cornish Engine, Simple and Compound—Types of Mining Engines—Pit Work—Shaft Sinking—Hydraulic Transmission of Power in Mines—Valve Gears of Pumping Engines—Water Pressure Pumping Engines—Water Works Engines—Pumping Engine Economy and Trials of Pumping Machinery—Centrifugal and other Low-Lift Pumps—Hydraulic Rams, Pumping Mains, &c.—INDEX.

"By the 'one English Engineer who probably knows more about Pumping Machinery than any other.' . . . A VOLUME RECORDING THE RESULTS OF LONG EXPERIENCE AND STUDY."—*The Engineer*.

"Undoubtedly THE BEST AND MOST PRACTICAL TREATISE on Pumping Machinery THAT HAS YET BEEN PUBLISHED."—*Mining Journal*.

*SECOND EDITION, Revised and Enlarged.
In Large 8vo, Handsome cloth, 34s.*

HYDRAULIC POWER AND HYDRAULIC MACHINERY.

BY

HENRY ROBINSON, M. INST. C.E., F.G.S.,

FELLOW OF KING'S COLLEGE, LONDON; PROF. OF CIVIL ENGINEERING,
KING'S COLLEGE, ETC., ETC.

With numerous Woodcuts, and Sixty-nine Plates.

"A Book of great Professional Usefulness."—*Irriga.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

Royal See, Handsome Cloth. With numerous Illustrations and Tables. 25s.

THE STABILITY OF SHIPS.

BY

SIR EDWARD J. REED, K.C.B., F.R.S., M.P.,

KNIGHT OF THE IMPERIAL ORDERS OF ST. STANISLAUS OF RUSSIA; FRANCIS JOSEPH OF AUSTRIA; MEHJIDIE OF TURKEY; AND RISING SUN OF JAPAN; VICE-PRESIDENT OF THE INSTITUTION OF NAVAL ARCHITECTS.

In order to render the work complete for the purposes of the Shipbuilder, whether at home or abroad, the Methods of Calculation introduced by Mr. F. K. BARNES, Mr. GRAY, M. REECH, M. DAYMARD, and Mr. BENJAMIN, are all given separately, illustrated by Tables and worked-out examples. The book contains more than 200 Diagrams, and is illustrated by a large number of actual cases, derived from ships of all descriptions.

"Sir EDWARD REED'S 'STABILITY OF SHIPS' is INVALUABLE. The NAVAL ARCHITECT will find brought together and ready to his hand, a mass of information which he would otherwise have to seek in an almost endless variety of publications, and some of which he would possibly not be able to obtain at all elsewhere."—*Seamanship*.

THE DESIGN AND CONSTRUCTION OF SHIPS. By JOHN HARVARD BILKS, M.INST.N.A., Professor of Naval Architecture in the University of Glasgow. *[In Preparation.]*

SECOND EDITION. Illustrated with Plates, Numerous Diagrams, and Figures in the Text. 18s. net.

STEEL SHIPS: THEIR CONSTRUCTION AND MAINTENANCE.

A Manual for Shipbuilders, Ship Superintendents, Students, and Marine Engineers.

BY THOMAS WALTON, NAVAL ARCHITECT,

AUTHOR OF "KNOW YOUR OWN SHIP."

CONTENTS.—I. Manufacture of Cast Iron, Wrought Iron, and Steel.—Composition of Iron and Steel, Quality, Strength, Tests, &c. II. Classification of Steel Ships. III. Considerations in making choice of Type of Vessel.—Framing of Ships. IV. Strains experienced by Ships.—Methods of Computing and Comparing Strengths of Ships. V. Construction of Ships.—Alternative Modes of Construction.—Types of Vessels.—Turret, Self Trimming, and Trunk Steamers, &c.—Rivets and Rivetting, Workmanship. VI. Pumping Arrangements. VII. Maintenance.—Prevention of Deterioration in the Hulls of Ships.—Cement, Paint, &c.—INDEX.

"So thorough and well written is every chapter in the book that it is difficult to select any of them as being worthy of exceptional praise. Altogether, the work is excellent, and will prove of great value to those for whom it is intended."—*The Engineer*.

"Mr. Walton has written for the profession of which he is an ornament. His work will be read and appreciated, no doubt, by every M.I.N.A., and with great benefit by the majority of them."—*Journal of Commerce*.

SECOND EDITION, Cloth, 8s. 6d. Leather, for the Pocket, 8s. 6d.

GRIFFIN'S ELECTRICAL PRICE-BOOK: For Electrical, Civil, Marine, and Borough Engineers, Local Authorities, Architects, Railway Contractors, &c., &c. Edited by H. J. DOWSING.

"The ELECTRICAL PRICE-BOOK REMOVES ALL MYSTERY about the cost of Electrical Power. By its aid the EXPENSE that will be entailed by utilising electricity on a large or small scale can be discovered."—*Architect*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

GRIFFIN'S NAUTICAL SERIES.

EDITED BY EDW. BLACKMORE,
Master Mariner, First Class Trinity House Certificate, Assoc. Inst. N.A.;
AND WRITTEN, MAINLY, by SAILORS for SAILORS.

- "THIS ADMIRABLE SERIES."—*Fairplay*. "A VERY USEFUL SERIES."—*Nature*.
 "The volumes of MESSRS. GRIFFIN'S NAUTICAL SERIES may well and profitably be read by ALL interested in our NATIONAL MARITIME PROGRESS."—*Marine Engineer*.
 "EVERY SHIP should have the WHOLE SERIES as a REFERENCE LIBRARY. HANDSOMELY BOUND, CLEARLY PRINTED and ILLUSTRATED."—*Liverpool Journ. of Commerce*.
The British Mercantile Marine: An Historical Sketch of its Rise and Development. By the EDITOR, CAPT. BLACKMORE. 8s. 6d.
 "Captain Blackmore's SPLENDID BOOK . . . contains paragraphs on every point of interest to the Merchant Marine. The 248 pages of this book are THE MOST VALUABLE to the sea captain that have EVER been COMPILED."—*Merchant Service Review*.
Elementary Seamanship. By D. WILSON-BARKER, Master Mariner, F.R.S.E., F.R.G.S. With numerous Plates, two in Colours, and Frontispiece. THIRD EDITION, Thoroughly Revised, Enlarged, and Re-set. With additional Illustrations. 6s.
 "THIS ADMIRABLE MANUAL, by CAPT. WILSON BARKER, of the 'Worcester,' seems to us PERFECTLY DESIGNED."—*Athenæum*.
Know Your Own Ship: A Simple Explanation of the Stability, Construction, Tonnage, and Freeboard of Ships. By THOS. WALTON, Naval Architect. With numerous Illustrations and additional Chapters on Buoyancy, Trim, and Calculations. SIXTH EDITION, Revised. 7s. 6d.
 "MR. WALTON'S book will be found VERY USEFUL."—*The Engineer*.
Navigation: Theoretical and Practical. By D. WILSON-BARKER, Master Mariner, &c., and WILLIAM ALLINGHAM. 8s. 6d.
 "PRECISELY the kind of work required for the New Certificates of competency. Candidates will find it INVALUABLE."—*Dundee Advertiser*.
Marine Meteorology: For Officers of the Merchant Navy. By WILLIAM ALLINGHAM, First Class Honours, Navigation, Science and Art Department. With Illustrations, Maps, and Diagrams, and facsimile reproduction of log page. 7s. 6d.
 "Quite the BEST PUBLICATION on this subject."—*Shipping Gazette*.
Latitude and Longitude: How to find them. By W. J. MILLAR, C.E., late Sec. to the Inst. of Engineers and Shipbuilders in Scotland. SECOND EDITION, Revised. 2s.
 "Cannot but prove an acquisition to those studying Navigation."—*Marine Engineer*.
Practical Mechanics: Applied to the requirements of the Sailor. By THOS. MACKENZIE, Master Mariner, F.R.A.S. SECOND EDITION, Revised. 8s. 6d.
 "WELL WORTH the money . . . EXCEEDINGLY HELPFUL."—*Shipping World*.
Trigonometry: For the Young Sailor, &c. By RICH. C. BUCK, of the Thames Nautical Training College, H.M.S. "Worcester." SECOND EDITION, Revised. Price 8s. 6d.
 "THIS EMINENTLY PRACTICAL and reliable volume."—*Schoolmaster*.
Practical Algebra. By RICH. C. BUCK. Companion Volume to the above, for Sailors and others. Price 3s. 6d.
 "It is JUST THE BOOK for the young sailor mindful of progress."—*Nautical Magazine*.
The Legal Duties of Shipmasters. By BENEDICT WM. GINSBURG, M.A., LL.D., of the Inner Temple and Northern Circuit; Barrister-at-Law. Price 4s. 6d.
 "INVALUABLE to masters. . . We can fully recommend it."—*Shipping Gazette*.
A Medical and Surgical Help for Shipmasters. Including First Aid at Sea. By WM. JOHNSON SMITH, F.R.C.S., Principal Medical Officer, Seamen's Hospital, Greenwich. SECOND EDITION, Revised. 6s.
 "BOUND, JUDICIOUS, REALLY HELPFUL."—*The Lancet*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

GRIFFIN'S NAUTICAL SERIES.*Price 3s. 6d. Post-free.*

T H H

British Mercantile Marine.

By EDWARD BLACKMORE,

MASTER MARINER; ASSOCIATE OF THE INSTITUTION OF NAVAL ARCHITECTS;
MEMBER OF THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS
IN SCOTLAND; EDITOR OF GRIFFIN'S "NAUTICAL SERIES."

GENERAL CONTENTS.—**HISTORICAL:** From Early Times to 1486—Progress under Henry VIII.—To Death of Mary—During Elizabeth's Reign—Up to the Reign of William III.—The 18th and 19th Centuries—Institution of Examinations—Rise and Progress of Steam Propulsion—Development of Free Trade—Shipping Legislation, 1862 to 1875—"Locksley Hall" Case—Shipmasters' Societies—Loading of Ships—Shipping Legislation, 1884 to 1894—Statistics of Shipping. **THE PERSONNEL:** Shipowners—Officers—Mariners—Duties and Present Position. **EDUCATION:** A Seaman's Education: what it should be—Present Means of Education—Hints. **DISCIPLINE AND DUTY.**—Postscript—The Serious Decrease in the Number of British Seamen, a Matter demanding the Attention of the Nation.

"INTERESTING AND INSTRUCTIVE . . . may be read with PROFIT and ENJOYMENT."—*Glasgow Herald.*

"EVERY BRANCH of the subject is dealt with in a way which shows that the writer 'knows the ropes' familiarly."—*Seafarer.*

"THIS ADMIRABLE book . . . TEEMS with useful information—Should be in the hands of every Sailor."—*Western Morning News.*

THIRD EDITION, *Thoroughly Revised, Enlarged, and Re-set.*
With Additional Illustrations. 6s.

**A MANUAL OF
ELEMENTARY SEAMANSHIP.**

BY

D. WILSON-BARKER, MASTER MARINER; F.R.S.E., F.R.G.S., &c., &c.;
YOUNGER BROTHER OF THE TRINITY HOUSE.

With Frontispiece, Numerous Plates (Two in Colours), and Illustrations
in the Text.

GENERAL CONTENTS.—The Building of a Ship; Parts of Hull, Masts, &c.—Ropes, Knots, Splicing, &c.—Gear, Lead and Log, &c.—Rigging, Anchors—Sailmaking—The Sails, &c.—Handling of Boats under Sail—Signals and Signalling—Rule of the Road—Keeping and Relieving Watch—Points of Etiquette—Glossary of Sea Terms and Phrases—Index.

* * The volume contains the NEW RULES OF THE ROAD.

"THIS ADMIRABLE MANUAL, by CAPT. WILSON-BARKER of the 'Worcester,' seems to us PERFECTLY DESIGNED, and holds its place excellently in 'GRIFFIN'S NAUTICAL SERIES.' . . . Although intended for those who are to become Officers of the Merchant Navy, it will be found useful by ALL YACHTSMEN."—*Athenæum.*

"FIVE SHILLINGS will be WELL SPENT on this little book. CAPT. WILSON-BARKER KNOWS from experience what a young man wants at the outset of his career."—*The Engineer.*

* * For complete List of GRIFFIN'S NAUTICAL SERIES, see p. 39.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

GRIFFIN'S NAUTICAL SERIES.*Price 3s. 6d. Post-free.***NAVIGATION:****PRACTICAL AND THEORETICAL.**

By DAVID WILSON-BARKER, R.N.R., F.R.S.E., &c., &c.,

AND

WILLIAM ALLINGHAM,

FIRST-CLASS HONOURS, NAVIGATION, SCIENCE AND ART DEPARTMENT.

With Numerous Illustrations and Examination Questions.

GENERAL CONTENTS.—Definitions—Latitude and Longitude—Instruments of Navigation—Correction of Courses—Plane Sailing—Traverse Sailing—Day's Work—Parallel Sailing—Middle Latitude Sailing—Mercator's Chart—Mercator Sailing—Current Sailing—Position by Bearings—Great Circle Sailing—The Tides—Questions—Appendix: Compass Error—Numerous Useful Hints, &c.—Index.

"PRECISELY the kind of work required for the New Certificates of competency in grades from Second Mate to extra Master. . . . Candidates will find it INVALUABLE."—*Dundas Advertiser*.

"A CAPITAL LITTLE BOOK . . . specially adapted to the New Examinations. The Authors are CAPT. WILSON-BARKER (Captain-Superintendent of the Nautical College, H.M.S. 'Worcester,' who has had great experience in the highest problems of Navigation), and MR. ALLINGHAM, a well-known writer on the Science of Navigation and Nautical Astronomy."—*Shipping World*.

*Handsome Cloth. Fully Illustrated. 7s. 6d. Post-free.***MARINE METEOROLOGY,****FOR OFFICERS OF THE MERCHANT NAVY.**

By WILLIAM ALLINGHAM,

Joint Author of "Navigation, Theoretical and Practical."

With numerous Plates, Maps, Diagrams, and Illustrations, and a facsimile Reproduction of a Page from an actual Meteorological Log-Book.

SUMMARY OF CONTENTS.

INTRODUCTORY.—Instruments Used at Sea for Meteorological Purposes.—Meteorological Log-Books.—Atmospheric Pressure.—Air Temperatures.—Sea Temperatures.—Winds.—Wind Force Scales.—History of the Law of Storms.—Hurricanes, Seasons, and Storm Tracks.—Solution of the Cyclone Problem.—Ocean Currents.—Icebergs.—Synchroous Charts.—Dew, Mists, Fogs, and Haze.—Clouds.—Rain, Snow, and Hail.—Mirage, Rainbows, Coronas, Halos, and Meteors.—Lightning, Comets, and Auroras.—**QUESTIONS.—APPENDIX.—INDEX.**

"Quite the BEST publication, AND certainly the MOST INTERESTING, on this subject ever presented to Nautical men."—*Shipping Gazette*.

* * For Complete List of GRIFFIN'S NAUTICAL SERIES, see p. 39.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

GRIFFIN'S NAUTICAL SERIES.

SECOND EDITION, REVISED. With Numerous Illustrations. 3s. 6d.

Practical Mechanics :

Applied to the Requirements of the Sailor.

BY THOS. MACKENZIE,

Master Mariner, F.R.A.S.

GENERAL CONTENTS.—Resolution and Composition of Forces—Work done by Machines and Living Agents—The Mechanical Powers: The Lever; Derricks as Bent Levers—The Wheel and Axle: Windlass; Ship's Capstan; Crab Winch—Tackles: the "Old Man"—The Inclined Plane; the Screw—The Centre of Gravity of a Ship and Cargo—Relative Strength of Rope: Steel Wire, Manilla, Hemp, Coir—Derricks and Shears—Calculation of the Cross-breaking Strain of Fir Spar—Centre of Effort of Sails—Hydrostatics: the Diving-bell; Stability of Floating Bodies; the Ship's Pump, &c.

"THIS EXCELLENT BOOK . . . contains a LARGE AMOUNT of information."
—*Nature*.

"WELL WORTH the money . . . will be found EXCEEDINGLY HELPFUL."
—*Shipping World*.

"NO SHIPS' OFFICERS' BOOKCASE will henceforth be complete without CAPTAIN MACKENZIE'S 'PRACTICAL MECHANICS.' Notwithstanding my many years' experience at sea, it has told me *how much more there is to acquire*."
—(Letter to the Publishers from a Master Mariner).

"I must express my thanks to you for the labour and care you have taken in 'PRACTICAL MECHANICS.' . . . IT IS A LIFE'S EXPERIENCE. . . . What an amount we frequently see wasted by rigging purchases without reason and accidents to spars, &c., &c.! 'PRACTICAL MECHANICS' WOULD SAVE ALL THIS."
—(Letter to the Author from another Master Mariner).

WORKS BY RICHARD C. BUCK,

of the Thames Nautical Training College, H.M.S. 'Worcester.'

A Manual of Trigonometry:*With Diagrams, Examples, and Exercises. Post-free 3s. 6d.*

SECOND EDITION, Revised and Corrected.

* * Mr. Buck's Text-Book has been SPECIALLY PREPARED with a view to the New Examinations of the Board of Trade, in which Trigonometry is an obligatory subject.

"THIS EXCELENTLY PRACTICAL and RELIABLE VOLUME"—*Schoolmaster*.

A Manual of Algebra.*Designed to meet the Requirements of Sailors and others. Price 3s. 6d.*

* * These elementary works on ALGEBRA and TRIGONOMETRY are written specially for those who will have little opportunity of consulting a Teacher. They are books for "SELF-HELP." All but the simplest explanations have, therefore, been avoided, and ANSWERS to the Exercises are given. Any person may readily, by careful study, become master of their contents, and thus lay the foundation for a further mathematical course, if desired. It is hoped that to the younger Officers of our Mercantile Marine they will be found decidedly serviceable. The Examples and Exercises are taken from the Examination Papers set for the Cadets of the "Worcester."

"Clearly arranged, and well got up. . . . A first-rate Elementary Algebra."
—*Nautical Magazine*.

* * For complete List of GRIFFIN'S NAUTICAL SERIES, see p. 29.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

GRIFFIN'S NAUTICAL SERIES.

In Crown 8vo. Handsome Cloth. 4s. 6d. Post-free.

THE LEGAL DUTIES OF SHIPMASTERS.

BY

BENEDICT WM. GINSBURG, M.A., LL.D. (CANTAB.),
Of the Inner Temple and Northern Circuit; Barrister-at-Law.

General Contents.—The Qualification for the Position of Shipmaster—The Contract with the Shipowner—The Master's Duty in respect of the Crew: Engagement; Apprentices; Discipline; Provisions, Accommodation, and Medical Comforts; Payment of Wages and Discharge—The Master's Duty in respect of the Passengers—The Master's Financial Responsibilities—The Master's Duty in respect of the Cargo—The Master's Duty in Case of Casualty—The Master's Duty to certain Public Authorities—The Master's Duty in relation to Pilots, Signals, Flags, and Light Dues—The Master's Duty upon Arrival at the Port of Discharge—Appendices relative to certain Legal Matters: Board of Trade Certificates, Dietary Scales, Stowage of Grain Cargoes, Load Line Regulations, Life-saving Appliances, Carriage of Cattle at Sea, &c., &c.—Copious Index.

"No Intelligent Master should fail to add this to his list of necessary books. A few lines of it may SAVE A LAWYER'S FEE, BESIDES ENDLESS WORRY."—*Liverpool Journal of Commerce.*

"SIMPLE, plainly written, in CLEAR and NON-TECHNICAL LANGUAGE, and will be found of MUCH SERVICE by the Shipmaster."—*British Trade Review.*

SECOND EDITION, Revised. With Diagrams. 2s. Post-free.

**Latitude and Longitude:
How to Find them.**

BY **W. J. MILLAR, C.E.,**

Late Secretary to the Inst. of Engineers and Shipbuilders in Scotland.

"CONCISELY and CLEARLY WRITTEN . . . cannot but prove an acquisition to those studying Navigation."—*Marine Engineer.*

"Young Seamen will find it HANDY and USEFUL, SIMPLE and CLEAR."—*The Engineer.*

FIRST AID AT SEA.

SECOND EDITION, Revised. With Coloured Plates and Numerous Illustrations, and comprising the latest Regulations Respecting the Carriage of Medical Stores on Board Ship. Post-free. 6s.

**A MEDICAL AND SURGICAL HELP
FOR SHIPMASTERS AND OFFICERS
IN THE MERCHANT NAVY.**

BY

WM. JOHNSON SMITH, F.R.C.S.,
Principal Medical Officer, Seamen's Hospital, Greenwich.

"* The attention of all interested in our Merchant Navy is requested to this exceedingly useful and valuable work. It is needless to say that it is the outcome of many years PRACTICAL EXPERIENCE amongst Seamen.

"SOUND, JUDICIOUS, REALLY HELPFUL."—*The Lancet.*

* For Complete List of GRIFFIN'S NAUTICAL SERIES, see p. 39.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

GRIFFIN'S NAUTICAL SERIES.

SEVEN EDITION. *Revised, with Chapters on Trim, Buoyancy, and Calculations. Numerous Illustrations. Handsome Cloth, Crown 8vo. 7s. 6d.*

KNOW YOUR OWN SHIP.

BY THOMAS WALTON, NAVAL ARCHITECT.

SPECIALY ARRANGED TO SUIT THE REQUIREMENTS OF SHIPS' OFFICERS, SHIPOWERS, SUPERINTENDENTS, DRAUGHTSMEN, ENGINEERS, AND OTHERS.

This work explains, in a simple manner, such important subjects as:—

Displacement,
Deadweight,
Tonnage,
Freeboard,
Moments,
Buoyancy,
Strain,
Structure,

Stability,
Rolling,
Ballasting,
Loading,
Shifting Cargoes,
Admission of Water,
Sail Area,
&c., &c.

"The little book will be found EXCEEDINGLY HANDY by most officers and officials connected with shipping. . . . Mr. Walton's work will obtain LASTING SUCCESS, because of its unique fitness for those for whom it has been written."—*Shipping World*.

"AN EXCELLENT WORK, full of solid instruction and INVALUABLE to every officer of the Mercantile Marine who has his profession at heart."—*Shipping*.

"Not one of the 242 pages could well be spared. It will admirably fulfil its purpose . . . useful to ship owners, ship superintendents, ship draughtsmen, and all interested in shipping."—*Liverpool Journal of Commerce*.

"A mass of VERY USEFUL INFORMATION, accompanied by diagrams and illustrations, is given in a compact form."—*Fairplay*.

"We have found no one statement that we could have wished differently expressed. The matter has, so far as clearness allows, been admirably condensed, and is simple enough to be understood by every seaman."—*Marine Engineer*.

BY THE SAME AUTHOR.

Steel Ships: Their Construction and Maintenance.

(See page 38.)

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

Fourteenth Edition, Revised. Price 21s.
Demy 8vo, Cloth. With Numerous Illustrations, reduced from Working Drawings.

A MANUAL OF MARINE ENGINEERING:

COMPRISING THE DESIGNING, CONSTRUCTION, AND
 WORKING OF MARINE MACHINERY.

By A. E. SEATON, M. Inst. C. E., M. Inst. Mech. E.,
 M. Inst. N. A.

GENERAL CONTENTS.

| | |
|--|--|
| Part I.—Principles of Marine Propulsion. | Calculations for Cylinders, Pistons, Valves, Expansion Valves, &c. |
| Part II.—Principles of Steam Engineering. | Part IV.—Propellers. |
| Part III.—Details of Marine Engines: Design and Cal- | Part V.—Boilers. |
| | Part VI.—Miscellaneous. |

*. This Edition includes a Chapter on WATER-TUBE BOILERS, with Illustrations of the leading Types and the Revised Rules of the *Bureau Veritas*.

"In the three-fold capacity of enabling a Student to learn how to design, construct, and work a Marine Steam-Engine, Mr. Seaton's Manual has NO RIVAL."—*Times*.

"The important subject of Marine Engineering is here treated with the thoroughness that it requires. No department has escaped attention. . . . Gives the results of much close study and practical work."—*Engineering*.

"By far the BEST MANUAL in existence. . . . Gives a complete account of the methods of solving, with the utmost possible economy, the problems before the Marine Engineer."—*Athenæum*.

"The Student, Draughtsman, and Engineer will find this work the MOST VALUABLE HANDBOOK of Reference on the Marine Engine now in existence."—*Marine Engineer*.

SEVENTH EDITION, Thoroughly Revised. Pocket-Size, Leather. 8s. 6d.

A POCKET-BOOK OF

MARINE ENGINEERING RULES AND TABLES,

FOR THE USE OF

Marine Engineers, Naval Architects, Designers, Draughtsmen,
 Superintendents and Others.

BY

A. E. SEATON, M.I.C.E., M.I.Mech.E., M.I.N.A.,

AND

H. M. BOUNTHWAITE, M.I.Mech.E., M.I.N.A.

"ADMIRABLY FULFILLS its purpose."—*Marine Engineer*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

WORKS BY PROF. ROBERT H. SMITH, Assoc.M.I.C.E.,
M.I.M.E., M.I.E.R., M.I.Min.E., Whit. Sch., M.Ord.Metl.

THE CALCULUS FOR ENGINEERS AND PHYSICISTS,

Applied to Technical Problems.

WITH EXTENSIVE

CLASSIFIED REFERENCE LIST OF INTEGRALS.

By PROF. ROBERT H. SMITH.

ASSISTED BY

R. F. MUIRHEAD, M.A., B.Sc.,

Formerly Clark Fellow of Glasgow University, and Lecturer on Mathematics at
 Mason College.

In Crown 8vo, extra, with Diagrams and Folding-Plate. 8s. 6d.

"Prof. R. H. SMITH's book will be serviceable in rendering a hard road as EASY AS FRAGMENTS for the non-mathematical Student and Engineer."—*Athenaeum*.

"Interesting diagrams, with practical illustrations of actual occurrence, are to be found here in abundance. THE VERY COMPLETE CLASSIFIED REFERENCE TABLE will prove very useful in saving the time of those who want an integral in a hurry."—*The Engineer*.

MEASUREMENT CONVERSIONS

(English and French):

28 GRAPHIC TABLES OR DIAGRAMS.

**Showing at a glance the MUTUAL CONVERSION of MEASUREMENTS
in DIFFERENT UNITS**

**Of Lengths, Areas, Volumes, Weights, Stresses, Densities, Quantities
of Work, Horse Powers, Temperatures, &c.**

For the use of Engineers, Surveyors, Architects, and Contractors.

In 4to, Boards. 7s. 6d.

"* Prof. SMITH'S CONVERSION-TABLES form the most unique and comprehensive collection ever placed before the profession. By their use much time and labour will be saved, and the chances of error in calculation diminished. It is believed that henceforth no Engineer's Office will be considered complete without them.

"The work is INVALUABLE."—*Colliery Guardian*.

"Ought to be in EVERY office where even occasional conversions are required. . . . Prof. SMITH'S TABLES form very EXCELLENT CHECKS on results."—*Electrical Review*.

"Prof. Smith deserves the hearty thanks, not only of the ENGINEER, but of the COMMERCIAL WORLD, for having smoothed the way for the ADOPTION of the METRIC SYSTEM of MEASUREMENTS, a subject which is now assuming great importance as a factor in maintaining our HOLD UPON FOREIGN TRADE."—*The Machinery Market*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

In Large 8vo. Handsome Cloth. 10s. 6d.

CHEMISTRY FOR ENGINEERS.

BY
BERTRAM BLOUNT, AND **A. G. BLOXAM,**
 F.I.C., F.C.S., A.I.C.E., F.I.C., F.C.S.,
 Consulting Chemist to the Crown Agents for Consulting Chemist, Head of the Chemistry
 the Colonies. Department, Goldsmiths' Inst.,
 New Cross.

GENERAL CONTENTS.—Introduction—Chemistry of the Chief Materials of Construction—Sources of Energy—Chemistry of Steam-raising—Chemistry of Lubrication and Lubricants—Metallurgical Processes used in the Winning and Manufacture of Metals.

"The authors have succeeded beyond all expectation, and have produced a work which should give FRESH POWER to the Engineer and Manufacturer."—*The Times*.

"PRACTICAL THROUGHOUT . . . an ADMIRABLE TEXT-BOOK, useful not only to Students, but to ENGINEERS and MANAGERS OF WORKS in PREVENTING WASTE and IMPROVING PROCESSES."—*Scottman*.

"A book worthy to take HIGH RANK . . . treatment of the subject of GASEOUS FUEL particularly good. . . . WATER GAS and its production clearly worked out. . . . We WARMLY RECOMMEND THE WORK."—*Journal of Gas Lighting*.

For Companion Volume by the same Authors, see "CHEMISTRY FOR MANUFACTURERS," p. 71.

WORKS BY **WALTER R. BROWNE, M.A., M.INST.C.E.,**
 Late Fellow of Trinity College, Cambridge.

THE STUDENT'S MECHANICS: An Introduction to the Study of Force and Motion.

With Diagrams. Crown 8vo. Cloth, 4s. 6d.

"Clear in style and practical in method, 'THE STUDENT'S MECHANICS' is cordially to be commended from all points of view."—*Athenaeum*.

FOUNDATIONS OF MECHANICS.

Papers reprinted from the *Engineer*. In Crown 8vo, 1s.

Demy 8vo, with Numerous Illustrations, 9s.

FUEL AND WATER: A Manual for Users of Steam and Water.

BY PROF. FRANZ SCHWACKHÖFER OF VIENNA, AND
 WALTER R. BROWNE, M.A., C.E.

GENERAL CONTENTS.—Heat and Combustion—Fuel, Varieties of—Firing Arrangements: Furnace, Flues, Chimney—The Boiler, Choice of—Varieties—Feed-water Heaters—Steam Pipes—Water: Composition, Purification—Prevention of Scale, &c., &c.

"The Section on Heat is one of the best and most lucid ever written."—*Engineer*.

"Cannot fail to be valuable to thousands using steam power."—*Railway Engineer*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

GRIFFIN'S LOCAL GOVERNMENT HANDBOOKS.

WORKS SUITABLE FOR MUNICIPAL AND COUNTY ENGINEERS,
ANALYSTS, AND OTHERS.

See also Davies' *Hygiene*, p. 99, and M'Leod's *Public Health*, p. 110.

Gas Manufacture (The Chemistry of). A Handbook on the Production, Purification, and Testing of Illuminating Gas, and the Assay of Bye-Products. By W. J. A. BUTTERFIELD, M.A., F.I.C., F.C.S. With Illustrations. SECOND EDITION, Revised and Enlarged. With Section on ACETYLENE. 16s. 6d. [See page 77.]
"Well deserving a place in every gas engineering library."—*Journal of Gas Lighting*.

Central Electrical Stations: Their Design, Organisation, and Management. By C. H. WORDINGHAM, A.K.C., M.Inst.C.E. Price 24s. net.
For details see opposite page.

Sewage Disposal Works: A Guide to the Construction of Works for the Prevention of the Pollution by Sewage of Rivers and Estuaries. By W. SANTO CRIMP, M.Inst.C.E., F.G.S. SECOND EDITION, Revised and Enlarged. Large 8vo, Handsome Cloth. With 37 Plates. Price 30s. [See page 76.]
"The MOST COMPLETE and BEST TREATISE on the subject which has appeared in our language."—*Edinburgh Medical Journal*.

Trades' Waste: Its Treatment and Utilisation, with Special Reference to the Prevention of Rivers' Pollution. By W. NAYLOR, F.C.S., A.M.Inst.C.E. With Numerous Plates, Diagrams, and Illustrations. 21s. net. [See page 77.]
"Replete with practical information of a technical character."—*Local Government Journal*.

Calcareous Cements: Their Nature, Preparation, and Uses. With some Remarks upon Cement Testing. By GILBERT REDGRAVE, Assoc.Inst.C.E. With Illustrations, Analytical Data, and Appendices on Costs, &c. 8s. 6d.
"Invaluable to student, architect, and engineer."—*Building News*. [See page 76.]

Road Making and Maintenance: A Practical Treatise for Engineers, Surveyors, and others. With an Historical Sketch of Ancient and Modern Practice. By THOMAS AITKEN, Assoc.M.Inst.C.E., M. Assoc. Municipal and County Engrs.; M. San. Inst. With numerous Plates, Diagrams, and Illustrations. 21s. [See page 79.]

"Should be on the reference shelf of EVERY MUNICIPAL AND COUNTY ENGINEER in the United Kingdom."—*The Surveyor*.

Light Railways at Home and Abroad. By WILLIAM HENRY COLE, M.Inst.C.E., late Deputy Manager, North-Western Railway, India. Large 8vo, Handsome Cloth, Plates and Illustrations. 16s. [See page 30.]
"Will remain for some time yet a Standard Work in everything relating to Light Railways."—*The Engineer*.

Practical Sanitation: A Handbook for Sanitary Inspectors and others interested in Sanitation. By GEO. REID, M.D., D.P.H., Medical Officer, Staffordshire County Council. With Appendix on Sanitary Law, by Herbert Manley, M.A., M.B., D.P.H. TENTH EDITION, Revised. 6s. [See page 78.]
"A HANDBOOK useful to SANITARY INSPECTORS, and ALL interested in Sanitary matters."—*Sanitary Record*.

Sanitary Engineering: A Practical Manual of Town Drainage and Sewage and Refuse Disposal. By FRANK WOOD, A.M.Inst.C.E., F.G.S., Borough Surveyor, Fulham. Fully Illustrated. 8s. 6d. net. [See page 78.]
"A VERITABLE POCKET COMPENDIUM of Sanitary Engineering."—*Public Health Engineer*.

Dairy Chemistry: A Practical Handbook for Dairy Managers, Chemists, and Analysts. By H. DROOP RICHMOND, F.C.S., Chemist to the Aylesbury Dairy Company. With Tables, Illustrations, &c. Handsome Cloth, 16s. [See page 73.]
"The BEST CONTRIBUTION to the subject that has yet appeared."—*The Lancet*.

Flesh Foods: With Methods for their Chemical, Microscopical, and Bacteriological Examination. A Handbook for Medical Men, Inspectors, Analysts, and others. By C. AINSWORTH MITCHELL, B.A., F.I.C., Mem. Council Soc. of Public Analysts. With numerous Illustrations and a coloured Plate. 10s. 6d. [See page 74.]
"WILL SAVE Medical Men, Analysts, Sanitary Inspectors, and others AN INFINITE AMOUNT OF REFERENCE."—*The Lancet*.

Foods: Their Composition and Analysis. By A. WYNTER BLYTH, M.R.C.S., F.C.S., Public Analyst for the County of Devon. With Tables, Folding Plate, and Frontispiece. FIFTH EDITION, Thoroughly Revised. [See page 72.]
"AN ADMIRABLE DIGEST of the most recent state of knowledge."—*Chemical News*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

§6. ELECTRICAL ENGINEERING.

In Large 8vo. Handsome Cloth. Profusely Illustrated with Plates, Diagrams, and Figures. 24s. net.

CENTRAL ELECTRICAL STATIONS:

Their Design, Organisation, and Management.

Including the Generation and Distribution of Electrical Energy.

By **CHAS. H. WORDINGHAM,**

A.K.C., M.INST.C.E., M.INST.MECH.E.,

Late Member of the Council of the Institute of Electrical Engineers, and Electrical Engineer to the City of Manchester.

CONTENTS.

Introductory.—Central Station Work as a Profession.—Central Station Supply as an Investment.—The Establishment of a Central Station.—Systems of Supply.—Choice of Site.—Architectural Features.—Choice of Plant and General Design.—Boilers.—Systems of Draught and Waste Heat Economy.—Methods of Firing Boilers.—Coal Handling, Weighing, and Storing.—Feeding of Boilers.—The Transmission of Steam.—Generators.—Condensing Appliances.—Switching Gear, Instruments, and Connections.—Distributing Mains.—Drawing-in Systems.—Built-in Systems, Dielectrics.—Insulation, Resistance, and Cost.—Distributing Networks.—Service Mains and Feeders.—Testing of Mains.—Recording and Laying of Mains.—Meters and Appliances on Consumers' Premises.—Standardising and Testing Laboratory.—Secondary Batteries.—Street Lighting.—Cost of Production.—Methods of Charging.—Regulations of Consumer's Installations.—General Organisations of a Central Station.—The Generating Station.—The Mains Department.—The Installation Department.—The Standardising Department.—The Drawing Office, Transforming Stations, and Street Lighting.—The Clerical Department.—The Consumer.—The Routine and Main Laying.—INDEX.

"One of the MOST VALUABLE CONTRIBUTIONS to Central Station literature we have had for some time. We wonder at the industry and perseverance which have produced the volume before us."—*Electricity*.

MUNRO & JAMIESON'S ELECTRICAL POCKET-BOOK.

SIXTEENTH EDITION, Thoroughly Revised and Enlarged.

A POCKET-BOOK

OF

ELECTRICAL RULES & TABLES

FOR THE USE OF ELECTRICIANS AND ENGINEERS.

By **JOHN MUNRO, C.E., & PROF. JAMIESON, M.INST.C.E., F.R.S.E.**

With Numerous Diagrams. Pocket Size. Leather, 8s. 6d.

GENERAL CONTENTS.

Units of Measurement.—Measures.—Testing.—Conductors.—Dielectrics.—Submarine Cables.—Telegraphy.—Electro-Chemistry.—Electro-Metallurgy.—Batteries.—Dynamoes and Motors.—Transformers.—Electric Lighting.—Miscellaneous.—Logarithms.—Appendices.

"WONDERFULLY PERFECT. . . . Worthy of the highest commendation we can give it."—*Electrician*.

"The STERLING VALUE of Messrs. MUNRO and JAMIESON'S POCKET-BOOK."—*Electrical Review*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

By **PROFESSORS J. H. POYNTING & J. J. THOMSON.**

In Five Volumes. Large 8vo. Sold Separately.

A TEXT-BOOK OF PHYSICS:

COMPRISING

**PROPERTIES OF MATTER; SOUND; HEAT; MAGNETISM
AND ELECTRICITY; AND LIGHT.**

BY

J. H. POYNTING,

Sc.D., F.R.S.,

Late Fellow of Trinity College, Cambridge;
Professor of Physics, Birmingham
University.

AND

J. J. THOMSON,

M.A., F.R.S.,

Fellow of Trinity College, Cambridge; Prof.
of Experimental Physics in the University
of Cambridge.

INTRODUCTORY VOLUME, fully Illustrated. SECOND EDITION, Revised.
Price 10s. 6d.

PROPERTIES OF MATTER.

CONTENTS.—Gravitation.—The Acceleration of Gravity.—Elasticity.—Stresses and Strains.—Torsion.—Bending of Rods.—Spiral Springs.—Collision.—Compressibility of Liquids.—Pressures and Volumes of Gases.—Thermal Effects Accompanying Strain.—Capillarity.—Surface Tension.—Laplace's Theory of Capillarity.—Diffusion of Liquids.—Diffusion of Gases.—Viscosity of Liquids.—INDEX.

VOLUME II. SECOND EDITION. Fully Illustrated. Price 8s. 6d.

SOUND.

CONTENTS.—The Nature of Sound and its chief Characteristics.—The Velocity of Sound in Air and other Media.—Reflection and Refraction of Sound.—Frequency and Pitch of Notes.—Resonance and Forced Oscillations.—Analysis of Vibrations.—The Transverse Vibrations of Stretched Strings or Wires.—Pipes and other Air Cavities.—Rods.—Plates.—Membranes.—Vibrations maintained by Heat.—Sensitive Flames and Jets.—Musical Sound.—The Superposition of Waves.—INDEX.

"The work . . . may be recommended to anyone desirous of possessing an **UP-TO-DATE STANDARD TREATISE ON ACOUSTICS.**"—*Literature.*

"Very clearly written. . . . The names of the authors are a guarantee of the **SCIENTIFIC ACCURACY and UP-TO-DATE CHARACTER** of the work."—*Educational Times.*

In large 8vo, with Bibliography, Illustrations in the Text, and seven
Lithographed Plates. 12s. 6d.

THE MEAN DENSITY OF THE EARTH:

An Essay to which the Adams Prize was adjudged in 1893 in
the University of Cambridge.

BY

J. H. POYNTING, Sc.D., F.R.S.,

Late Fellow of Trinity College, Cambridge; Professor of Physics,
Birmingham University.

"An account of this subject cannot fail to be of **GRAND and GENERAL INTEREST** to the scientific mind. Especially is this the case when the account is given by one who has contributed so considerably as has Prof. Poynting to our present state of knowledge with respect to a very difficult subject. . . . Remarkably has Newton's estimate been verified by Prof. Poynting."—*Athenæum.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

§§ 7-8. Griffin's Geological, Prospecting, Mining, and Metallurgical Publications.

| | PAGE |
|--------------------------------------|---|
| Geology, Stratigraphical, . . . | R. ETHERIDGE, F.R.S., . . . 52 |
| „ Physical, . . . | PROF. H. G. SERLEY, . . . 52 |
| „ Practical Aids, . . . | PROF. GRENVILLE COLE, . . . 53 |
| „ Open Air Studies, . . . | „ „ „ . . . 85 |
| Griffin's "New Land" Series, . . . | Ed. by PROF. COLE, . . . 54 |
| Prospecting for Minerals, . . . | S. HERBERT COX, A.R.S.M., . . . 55 |
| Food Supply, . . . | ROBT. BRUCE, . . . 55 |
| New Lands, . . . | H. R. MILL, D.Sc., F.R.S.E., . . . 54 |
| Building Construction, . . . | PROF. JAMES LYON, . . . 54 |
| Ore and Stone Mining, . . . | PROF. LE NEVE FOSTER, . . . 56 |
| Elementary Mining, . . . | „ „ „ . . . 56 |
| Coal Mining, . . . | H. W. HUGHES, F.G.S., . . . 57 |
| Practical Coal Mining, . . . | G. L. KERR, M.Inst.M.E., . . . 58 |
| Elementary „ „ „ . . . | „ „ „ . . . 58 |
| Electrical Coal Mining, . . . | D. BURNS, . . . 59 |
| Petroleum, . . . | REDWOOD AND HOLLOWAY, . . . 61 |
| A Handbook on Petroleum, . . . | J. H. THOMSON AND DR. REDWOOD, . . . 61 |
| The Petroleum Lamp, . . . | „ „ „ . . . 61 |
| Mine-Surveying, . . . | BENNETT H. BROUGH, A.R.S.M., . . . 56 |
| Blasting and Explosives, . . . | O. GUTTMANN, A.M.I.C.E., . . . 57 |
| Mine Accounts, . . . | PROF. J. G. LAWN, . . . 58 |
| Mining Engineers' Pkt.-Bk., . . . | E. R. FIELD, M.Inst.M.M., . . . 60 |
| Metallurgy (General), . . . | PHILLIPS AND BAUERMAN, . . . 60 |
| „ (Elementary), . . . | PROF. HUMBOLDT SEXTON, . . . 66 |
| Assaying, . . . | J. J. & C. BERINGER, . . . 66 |
| Metallurgical Analysis, . . . | J. J. MORGAN, F.C.S., . . . 67 |
| Griffin's Metallurgical Series . . . | Ed. by SIR W. ROBERTS-AUSTEN, . . . 62 |
| Introduction, . . . | SIR W. ROBERTS-AUSTEN, K.O.B., . . . 63 |
| Gold, Metallurgy of, . . . | DR. KIRKE ROSE, A.R.S.M., . . . 63 |
| Lead and Silver, „ „ . . . | H. F. COLLINS, A.R.S.M., . . . 64 |
| Iron, Metallurgy of, . . . | THOS. TURNER, A.R.S.M., . . . 65 |
| Steel, „ „ „ . . . | F. W. HARBORD AND J. W. HALL, . . . 65 |
| Metallurgical Machinery, . . . | H. C. JENKINS, A.R.S.M., . . . 65 |
| Getting Gold, . . . | J. C. F. JOHNSON, F.G.S., . . . 59 |
| Gold Seeking in South Africa, . . . | THEO KASSNER, . . . 60 |
| Cyanide Process, . . . | JAMES PARK, F.G.S., . . . 59 |
| Electric Smelting, . . . | BORCHERS AND McMILLAN, . . . 68 |
| Electro-Metallurgy, . . . | W. G. McMILLAN, F.I.C., . . . 68 |
| Goldsmith and Jeweller's Art, . . . | THOS. B. WIGLEY, . . . 67 |

Demy 8vo, Handsome cloth, 18s.

Physical Geology and Palæontology, ON THE BASIS OF PHILLIPS.

BY

HARRY GOVIER SEELEY, F.R.S.,
PROFESSOR OF GEOGRAPHY IN KING'S COLLEGE, LONDON.

With Frontispiece in Chromo-Lithography, and Illustrations.

"It is impossible to praise too highly the research which PROFESSOR SEELEY'S 'PHYSICAL GEOLOGY' evidences. IT IS FAR MORE THAN A TEXT-BOOK—it is a DIRECTORY to the Student in prosecuting his researches."—*Præsidential Address to the Geological Society, 1885, by Rev. Prof. Benney, D.Sc., LL.D., F.R.S.*

"PROFESSOR SEELEY maintains in his 'PHYSICAL GEOLOGY' the high reputation he already deservedly bears as a Teacher."—*Dr. Henry Woodward, F.R.S., in the "Geological Magazine."*

"PROFESSOR SEELEY'S work includes one of the most satisfactory Treatises on Lithology in the English language."—*American Journal of Engineering.*

Demy 8vo, Handsome cloth, 34s.

Stratigraphical Geology & Palæontology, ON THE BASIS OF PHILLIPS.

BY

ROBERT ETHERIDGE, F.R.S.,
OF THE NATURAL HIST. DEPARTMENT, BRITISH MUSEUM, LATE PALÆONTOLOGIST TO THE
GEOLOGICAL SURVEY OF GREAT BRITAIN, PAST PRESIDENT OF THE
GEOLOGICAL SOCIETY, ETC.

With Map, Numerous Tables, and Thirty-six Plates.

"No such compendium of geological knowledge has ever been brought together before."—*Westminster Review.*

"If PROF. SEELEY'S volume was remarkable for its originality and the breadth of its views, MR. ETHERIDGE fully justifies the assertion made in his preface that his book differs in construction and detail from any known manual. . . . Must take HIGH RANK AMONG WORKS OF REFERENCE."—*Athenæum.*

OPEN-AIR STUDIES IN GEOLOGY:

An Introduction to Geology Out-of-doors.

By PROFESSOR GRENVILLE COLE, M.R.I.A., F.G.S.

For details, see Griffin's Introductory Science Series, p. 85.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

Crown 8vo. Handsome Cloth. 2s. 6d.

RESEARCHES ON THE PAST AND PRESENT HISTORY
OF
THE EARTH'S ATMOSPHERE.

Including the latest Discoveries and their Practical Applications.

By DR. THOMAS LAMB PHIPSON.

PART I.—THE EARTH'S ATMOSPHERE IN REMOTE GEOLOGICAL PERIODS.

PART II.—THE ATMOSPHERE OF OUR PRESENT PERIOD.

APPENDICES; INDEX.

* * Dr. Phipson's work presents, amidst much which is of interest to the Scientist and the General Reader alike, a short *résumé* of his discovery of the origin of Atmospheric Oxygen, the existence of which he attributes wholly to the action of Solar Radiation upon vegetable life. The book will be found replete with much that is new, curious, and interesting, both in connection with Weather Lore, and with Scientific Meteorology.—*Publisher's Note.*

"The book should prove of interest to general readers, as well as to meteorologists and other students of science."—*Nature.*

By GRENVILLE A. J. COLE, M.R.I.A., F.G.S.

Professor of Geology in the Royal College of Science for Ireland, and Examiner in the University of London.

See also the two following pages (54, 55), and page 85.

**AIDS IN
PRACTICAL GEOLOGY:**

WITH A SECTION ON PALÆONTOLOGY.

By PROFESSOR GRENVILLE COLE, M.R.I.A., F.G.S.

FOURTH EDITION, Thoroughly Revised. With Frontispiece and Illustrations. Cloth, 10s. 6d.

GENERAL CONTENTS.—

PART I.—SAMPLING OF THE EARTH'S CRUST.

PART II.—EXAMINATION OF MINERALS.

PART III.—EXAMINATION OF ROCKS.

PART IV.—EXAMINATION OF FOSSILS.

"Prof. Cole treats of the examination of minerals and rocks in a way that has never been attempted before . . . DESERVING OF THE HIGHEST PRAISE. Here indeed are 'Aids' INNUMERABLE and INVALUABLE. All the directions are given with the utmost clearness and precision."—*Athenæum.*

"That the work deserves its title, that it is full of 'Aids,' and in the highest degree 'PRACTICAL,' will be the verdict of all who use it."—*Nature.*

"This EXCELLENT MANUAL . . . will be a VERY GREAT HELP. . . . The section on the Examination of Fossils is probably the BEST of its kind yet published. . . . Full of well-digested information from the newest sources and from personal research."—*Annals of Nat. History.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

GRIFFIN'S "NEW LAND" SERIES.

*Practical Hand-Books for the Use of Prospectors, Explorers,
Settlers, Colonists, and all Interested in the opening
up and Development of New Lands.*

EDITED BY GRENVILLE A. J. COLE, M.R.I.A., F.G.S.,
Professor of Geology in the Royal College of Science for Ireland, and Examiner in
the University of London.

In Crown 8vo. Handsome Cloth. 5s.

With Numerous Maps Specially Drawn and Executed for this Work.

NEW LANDS:

THEIR RESOURCES AND PROSPECTIVE ADVANTAGES.

By HUGH ROBERT MILL, D.Sc., LL.D., F.R.S.E.,
Librarian to the Royal Geographical Society.

INTRODUCTORY.—The Development of New Lands.—The Dominion of Canada.—Canada, Eastern Provinces.—Canada, Western Provinces and Territories.—Newfoundland.—The United States.—Latin America, Mexico.—Latin America, Temperate Brazil and Chili.—Latin America, Argentina.—The Falkland Islands.—Victoria.—New South Wales.—Queensland.—South Australia.—Tasmania.—Western Australia.—New Zealand.—The Resources of South Africa.—Southern Rhodesia.—INDEX.

"PAINSTAKING . . . COMPLETE . . . of great PRACTICAL ASSISTANCE."—*The Field*.

"A want admirably supplied. . . . Has the advantage of being written by a *pr*o-
fessed Geographer."—*Geographical Journal*.

IN PREPARATION.

**BUILDING CONSTRUCTION IN WOOD, STONE, AND
CONCRETE.** By JAMES LYON, M.A., Professor of En-
gineering in the Royal College of Science for Ireland;
sometime Superintendent of the Engineering Department in
the University of Cambridge; and J. TAYLOR, A.R.C.S.I.

* * * Other Volumes, dealing with subjects of **PRIMARY
IMPORTANCE** in the **EXAMINATION** and **UTILISATION** of Lands
which have not as yet been fully developed, are in preparation.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

GRIFFIN'S "NEW LAND" SERIES.

THIRD EDITION, Revised. With Illustrations. Price in Cloth, 5s.; strongly bound in Leather, 6s. 6d.

PROSPECTING FOR MINERALS.

A Practical Handbook for Prospectors, Explorers, Settlers, and all interested in the Opening up and Development of New Lands.

BY

S. HERBERT COX, Assoc.R.S.M., M.Inst.M.M., F.G.S., &c.

GENERAL CONTENTS.—Introduction and Hints on Geology—The Determination of Minerals: Use of the Blow-pipe, &c.—Rock-forming Minerals and Non-Metallic Minerals of Commercial Value: Rock Salt, Borax, Marbles, Lithographic Stone, Quartz and Opal, &c., &c.—Precious Stones and Gems—Stratified Deposits: Coal and Ores—Mineral Veins and Lodes—Irregular Deposits—Dynamics of Lodes: Faults, &c.—Alluvial Deposits—Noble Metals: Gold, Platinum, Silver, &c.—Lead—Mercury—Copper—Tin—Zinc—Iron—Nickel, &c.—Sulphur, Antimony, Arsenic, &c.—Combustible Minerals—Petroleum—General Hints on Prospecting—Glossary—Index.

"This ADMIRABLE LITTLE WORK . . . written with SCIENTIFIC ACCURACY in a CLEAR and LUCID style. . . . An IMPORTANT ADDITION to technical literature . . . will be of value not only to the Student, but to the experienced Prospector. . . . If the succeeding volumes of the NEW LAND SERIES are equal in merit to the First, we must congratulate the Publishers on successfully filling up a gap in existing literature."
—*Mining Journal*.

"This EXCELLENT HANDBOOK will prove a perfect *Vade-mecum* to those engaged in the practical work of Mining and Metallurgy."
—*Times of Africa*.

With many Engravings and Photographs. Handsome Cloth, 4s. 6d.

FOOD SUPPLY.

By ROBERT BRUCE,

Agricultural Superintendent to the Royal Dublin Society.

With Appendix on Preserved Foods by C. A. MITCHELL, B.A., F.I.C.

GENERAL CONTENTS.—Climate and Soil—Drainage and Rotation of Crops—Seeds and Crops—Vegetables and Fruits—Cattle and Cattle-Breeding—Sheep and Sheep Rearing—Pigs—Poultry—Horses—The Dairy—The Farmer's Implements—The Settler's Home.

"BRISTLES WITH INFORMATION."—*Farmers' Gazette*.

"The work is one which will appeal to those intending to become farmers at home or in the Colonies, and who desire to obtain a general idea of the true principles of farming in ALL ITS BRANCHES."
—*Journal of the Royal Colonial Inst.*

"A most READABLE and VALUABLE book, and merits an EXTENSIVE SALE."
—*Scottish Farmer*.

"Will prove of service in ANY PART OF THE WORLD."
—*Nature*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

FOURTH EDITION, Revised, and brought thoroughly up-to-date by L. H. COOKE, Instructor in Mine Surveying, Royal College of Science.
With Frontispiece and 716 Illustrations. Price 34s.

ORE & STONE MINING.

BY

C. LE NEVE FOSTER, D.Sc., F.R.S.,

PROFESSOR OF MINING, ROYAL COLLEGE OF SCIENCE; EXAMINER IN MINING TO THE BOARD OF EDUCATION.

GENERAL CONTENTS.

INTRODUCTION. Mode of Occurrence of Minerals.—Prospecting.—Boring.—Breaking Ground.—Supporting Excavations.—Exploitation.—Haulage or Transport.—Hoisting or Winding.—Drainage.—Ventilation.—Lighting.—Descent and Ascent.—Dressing—Principles of Employment of Mining Labour.—Legislation affecting Mines and Quarries.—Condition of the Mines.—Accidents.—Index.

"Dr. Foster's book was expected to be EPOCH-MAKING, and it fully justifies such expectation. . . . A MOST ADMIRABLE account of the mode of occurrence of practically ALL KNOWN MINERALS. Probably stands UNEQUALLED for completeness."—*The Mining Journal*.

"This EPOCH-MAKING work . . . appeals to MEN OF EXPERIENCE no less than to students."—*Berg- und Hüttenmännische Zeitung*.

"This SPLENDID WORK."—*Oesterr. Ztschrift. für Berg- und Hüttenwesen*.

ELEMENTARY MINING AND QUARRYING

(An Introductory Text-book). By Prof. C. LE NEVE FOSTER, F.R.S. [In Active Preparation.

NINTH EDITION, Revised and Enlarged. With Numerous Diagrams.
Cloth, 7s. 6d.

A TREATISE ON MINE-SURVEYING:

For the use of Managers of Mines and Collieries, Students at the Royal School of Mines, &c.

BY BENNETT H. BROUGH, F.G.S., ASSOC.R.S.M.,
Formerly Instructor of Mine-Surveying, Royal School of Mines.

GENERAL CONTENTS.

General Explanations—Measurement of Distances—Miner's Dial—Variation of the Magnetic-Needle—Surveying with the Magnetic-Needle in presence of Iron—Surveying with the Fixed Needle—German Dial—Theodolite—Traversing Underground—Surface-Surveys with Theodolite—Plotting the Survey—Calculation of Areas—Levelling—Connection of Underground and Surface-Surveys—Measuring Distances by Telescope—Setting-out—Mine-Surveying Problems—Mine Plans—Applications of Magnetic-Needle in Mining—Photographic Surveying—Appendices.

"ITS CLEARNESS OF STYLE, LUCIDITY OF DESCRIPTION, and FULLNESS OF DETAIL have long ago won for it a place unique in the literature of this branch of mining engineering, and the present edition fully maintains the high standard of its predecessors. To the student, and to the mining engineer alike, ITS VALUE is inestimable. The illustrations are excellent."—*The Mining Journal*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

FOURTH EDITION, Revised and Greatly Enlarged. With Numerous Additional Illustrations, mostly reduced from Working Drawings. Price 24s. net.

A TEXT-BOOK OF COAL-MINING:

FOR THE USE OF COLLIERY MANAGERS AND OTHERS
ENGAGED IN COAL-MINING.

BY

HERBERT WILLIAM HUGHES, F.G.S.,
Assoc. Royal School of Mines, General Manager of Sandwell Park Colliery.

GENERAL CONTENTS.

Geology.—Search for Coal.—Breaking Ground.—Sinking.—Preliminary Operations.—Methods of Working.—Haulage.—Winding.—Pumping.—Ventilation.—Lighting.—Works at Surface.—Preparation of Coal for Market.—INDEX.

"Quite THE BEST BOOK of its kind . . . as PRACTICAL in aim as a book can be . . . The illustrations are EXCELLENT."—*Athenaeum*.

"We cordially recommend the work."—*Colliery Guardian*.

"Will soon come to be regarded as the STANDARD WORK of its kind."—*Birmingham Daily Gazette*.

In Large 8vo, with Illustrations and Folding-Plates. 10s. 6d.

BLASTING:

AND THE USE OF EXPLOSIVES.

A Handbook for Engineers and others Engaged in Mining,
Tunnelling, Quarrying, &c.

By OSCAR GUTTMANN, Assoc. M. INST. C.E.

Member of the Societies of Civil Engineers and Architects of Vienna and Budapest;
Corresponding Member of the Imp. Roy. Geological Institution of Austria, &c.

GENERAL CONTENTS.—Historical Sketch—Blasting Materials—Blasting Powder—Various Powder-mixtures—Gun-cotton—Nitro-glycerine and Dynamite—Other Nitro-compounds—Sprengel's Liquid (acid) Explosives—Other Means of Blasting—Qualities, Dangers, and Handling of Explosives—Choice of Blasting Materials—Apparatus for Measuring Force—Blasting in Fiery Mines—Means of Igniting Charges—Preparation of Blasts—Bore-holes—Machine-drilling—Chamber Mines—Charging of Bore-holes—Determination of the Charge—Blasting in Bore-holes—Firing—Straw and Fuze Firing—Electrical Firing—Substitutes for Electrical Firing—Results of Working—Various Blasting Operations—Quarrying—Blasting Masonry, Iron and Wooden Structures—Blasting in earth, under water, of ice, &c.

"This ADMIRABLE work."—*Colliery Guardian*.

"Should prove a *vade-mecum* to Mining Engineers and all engaged in practical work."—*Iron and Coal Trades Review*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

In Large 8vo. SECOND EDITION. Price 10s. 6d.

Mine Accounts and Mining Book-keeping.

For Students, Managers, Secretaries, and others.

With Examples taken from Actual Practice of Leading Companies.

BY

JAMES GUNSON LAWN, Assoc. R.S.M., Assoc. Mem. Inst. C.E., F.G.S.,
Professor of Mining at the South African School of Mines, Capetown,
Kimberley, and Johannesburg.

EDITED BY C. LE NEVE FOSTER, D.Sc., F.R.S.,
Professor of Mining, Royal School of Mines, and Examiner in Mining to the
Board of Education.

GENERAL CONTENTS.—Introduction.—Part I. Engagement and Payment of Workmen.—Part II. Purchases and Sales.—Part III. Working Summaries and Analyses.—Part IV. Ledger, Balance Sheet, and Company Books.—Part V. Reports and Statistics.

"It seems IMPOSSIBLE to suggest how Mr. LAWN's book could be made more COMPLETE or more VALUABLE, careful, and exhaustive."—*Accountants' Magazine*.

SECOND EDITION. Large Crown 8vo. Handsome Cloth. With over
520 Illustrations in the Text. 12s. 6d.

PRACTICAL COAL-MINING:

A MANUAL FOR MANAGERS, UNDER-MANAGERS,
COLLIERY ENGINEERS, AND OTHERS.

With Worked-out Problems on Haulage, Pumping, Ventilation, &c.

By GEORGE L. KERR, M.E., M.Inst.M.E.,
Colliery Manager.

"An ESSENTIALLY PRACTICAL WORK, and can be confidently recommended. No department of Coal-Mining has been overlooked."—*Engineers' Gazette*.

"This book JUST MEETS the wants of Students preparing for the Colliery Managers' Examinations. I have decided to use it for our classes here. . . . We have, I believe, the largest mining class in Great Britain."—*The Principal of a Training College*.

In Crown 8vo. Handsome Cloth. With 200 Illustrations. 3s. 6d.

ELEMENTARY COAL-MINING:

For the Use of Students, Miners, and others preparing
for Examinations.

By GEORGE L. KERR, M.E., M.Inst.M.E.,
Author of "Practical Coal-Mining."

*Specially designed to meet the Requirements of Students attending
Classes on Coal-Mining.*

"An abundance of information conveyed in a popular and attractive form. . . . Will be of great use to all who are in any way interested in coal mining."—*Scottish Critic*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

Ready Immediately. In Crown 8vo. Handsome Cloth. With Numerous Illustrations.

ELECTRICAL PRACTICE IN COLLIERIES.

By D. BURNS, M.E., M.INST.M.E.,

Certificated Colliery Manager, and Lecturer on Mining to the County Council of Lanark.

Units of Measurement, Conductors, &c.—The Theory of the Dynamo.—The Dynamo, Details of Construction and Working.—Motors.—Lighting Installations in Collieries.—Pumping by Electricity.—Electrical Haulage.—Coal Cutting.—Miscellaneous Applications of Electricity in Mines.—INDEX.

With Illustrations and Plates. Handsome Cloth.

THE CYANIDE PROCESS OF GOLD EXTRACTION.

A Text-Book for the Use of Metallurgists and Students at Schools of Mines, &c.

By JAMES PARK, F.G.S., M.INST.M.M.,

Professor of Mining and Director of the Otago University School of Mines; late Director, Thames School of Mines, and Geological Surveyor and Mining Geologist to the Government of New Zealand.

ENGLISH EDITION. Thoroughly Revised and Greatly Enlarged from the Third (1897) (New Zealand) Edition. With additional details concerning the Siemens-Halske and other recent processes.

CONTENTS.—The MacArthur Process.—Chemistry of the Process.—Laboratory Experiments.—Control Testing and Analysis of Solutions.—Appliances for Cyanide Extraction.—The Actual Extraction by Cyanide.—Application of the Process.—Leaching by Agitation.—Zinc Precipitation of Gold.—The Siemens-Halske Process.—Other Cyanide Processes.—Antidotes for Cyanide Poisoning.—Cyaniding in New Zealand.

"Mr. Park's book deserves to be ranked as amongst the BEST OF EXISTING TREATISES ON THIS SUBJECT."—*Mining Journal*.

SECOND EDITION. *With Illustrations. Cloth, 3s. 6d.*

GETTING GOLD:

A GOLD-MINING HANDBOOK FOR PRACTICAL MEN.

By J. C. F. JOHNSON, F.G.S., A.I.M.E.,

Life Member Australasian Mine-Managers' Association.

GENERAL CONTENTS.—Introductory: Getting Gold—Gold Prospecting (Alluvial and General)—Lode or Reef Prospecting—The Genesis of Gold—Auriferous Lodes—Auriferous Drifts—Gold Extraction—Secondary Processes and Lixiviation—Calcination or "Roasting" of Ores—Motor Power and its Transmission—Company Formation and Operations—Rules of Thumb: Mining Appliances and Methods—Selected Data for Mining Men—Australasian Mining Regulations.

"PRACTICAL from beginning to end . . . deals thoroughly with the Prospecting, Sinking, Crushing, and Extraction of gold."—*Brit. Australasian*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

Pocket Size, Strongly bound in Leather. 2s. 6d.

THE MINING ENGINEERS' REPORT BOOK

AND DIRECTORS' AND SHAREHOLDERS' GUIDE TO MINING REPORTS.

By EDWIN R. FIELD, M.Inst.M.M.

With Notes on the Valuation of Mining Property and Tabulating Reports, Useful Tables, &c., and provided with detachable blank pages for MS. Notes.

"An ADMIRABLY compiled book which Mining Engineers and Managers will find EXTREMELY USEFUL."—*Mining Journal*.

In Crown 8vo. Illustrated. Fancy Cloth Boards. 4s. 6d.

GOLD SEEKING IN SOUTH AFRICA:

A Handbook of Hints for intending Explorers, Prospectors, and Settlers.

By THEO KASSNER,

Mine Manager, Author of the Geological Sketch Map of the De Kaap Gold Fields.

With a Chapter on the Agricultural Prospects of South Africa.

ABSTRACT OF CONTENTS.—History.—Geology.—Prospecting.—The De Kaap Goldfields.—Komati and Swaziland.—Cost of Mining, Native Labour, &c.—Lydenberg Goldfields—Zoutspanberg.—Witwatersrand.—Other Goldfields.—General Considerations.—Conclusions.—Agricultural Prospects, Tables, Index, &c.

"As fascinating in its way as anything ever penned by Jules Verne. Mr. Kassner manages to impart his information in a way that enables him to be understood even of the dullest."—*African Commerce*.

THIRD EDITION. With Folding Plates and Many Illustrations. 38s.

ELEMENTS OF METALLURGY.

A PRACTICAL TREATISE ON THE ART OF EXTRACTING METALS FROM THEIR ORES.

By J. ARTHUR PHILLIPS, M.Inst.C.E., F.C.S., F.G.S., &c.,
AND H. BAUERMAN, V.P.G.S.

GENERAL CONTENTS.—Refractory Materials.—Fire-Clays.—Fuels, &c.—Aluminium.—Copper.—Tin.—Antimony.—Arsenic.—Zinc.—Mercury.—Bismuth.—Lead.—Iron.—Cobalt.—Nickel.—Silver.—Gold.—Platinum.

"Of the THIRD EDITION, we are still able to say that, as a Text-book of Metallurgy, it is THE BEST with which we are acquainted."—*Engineer*.

"A work which is equally valuable to the Student as a Text-book, and to the practical Smelter as a Standard Work of Reference. . . . The Illustrations are admirable examples of Wood Engraving."—*Chemical News*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

SECOND EDITION. *In Preparation. In Two Volumes, Large 8vo. With Numerous Maps, Plates, and Illustrations in the Text. Price 45s.*

PETROLEUM

AND ITS PRODUCTS:

A PRACTICAL TREATISE.

By **Dr. BOVERTON REDWOOD,**

F.R.S.E., F.I.O., Assoc.R.C.S.,

Mem. Corr. Mem. of the Imperial Russian Technical Society; Mem. of the American Chemical Society; Adviser to the Home Office and to the Corporation of London under the Petroleum Acts, &c., &c.

ASSISTED BY **GEO. T. HOLLOWAY, F.I.C., Assoc. R.C.S.,**
And Numerous Contributors.

GENERAL CONTENTS—I. Historical.—II. Geological and Geographical Distribution of Petroleum and Natural Gas.—III. Chemical and Physical Properties.—IV. Origin.—V. Production.—VI. Refining.—VII. The Shale Oil and Allied Industries.—VIII. Transport, Storage, and Distribution.—IX. Testing.—X. Application and Uses.—XI. Legislation at Home and Abroad.—XII. Statistics.—INDEX.

"The MOST COMPREHENSIVE AND CONVENIENT ACCOUNT that has yet appeared of a gigantic industry which has made incalculable additions to the comfort of civilised man."—*The Times*.

"A SPLENDID CONTRIBUTION to our technical literature."—*Chemical News*.

With Plates (One Coloured) and Illustrations. Price 8s. 6d. net.

A HANDBOOK ON PETROLEUM.

FOR INSPECTORS UNDER THE PETROLEUM ACTS,

And for those engaged in the Storage, Transport, Distribution, and Industrial Use of Petroleum and its Products, and of Calcium Carbide. With suggestions on the Construction and Use of Mineral Oil Lamps.

By **CAPTAIN J. H. THOMSON,**

H.M. Chief Inspector of Explosives,

AND

DR. BOVERTON REDWOOD,

Author of "Petroleum and its Products."

CONTENTS.—I. Introductory.—II. Sources of Supply.—III. Production.—IV. Chemical Products, Shale Oil, and Coal Tar.—V. Flash Point and Fire Test.—VI. Testings.—VII. Existing Legislation relating to Petroleum.—VIII.—IX.—Precautions Necessary.—X. Petroleum Oil Lamps.—XI. Carbide of Calcium and Acetylene.—Appendices.—INDEX.

"A volume that will enrich the world's petroleum literature, and render a service to the British branch of the industry. . . . Reliable, indispensable, a brilliant contribution."—*Petroleum*.

THE PETROLEUM LAMP: Its Choice and Use. A Guide to the Safe Employment of Mineral Oil in what is commonly termed the Paraffin Lamp. By **CAPT. J. H. THOMSON** and **DR. BOVERTON REDWOOD.** Popular Edition, Illustrated. 1s. net.

"The book contains a great deal of interesting reading, much of which is thoroughly practical and useful. It is a work which will meet every purpose for which it has been written."—*Petroleum*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

Griffin's Metallurgical Series.

STANDARD WORKS OF REFERENCE

FOR

**Metallurgists, Mine-Owners, Assayers, Manufacturers,
and all interested in the development of
the Metallurgical Industries.**

EDITED BY

Sir W. ROBERTS-AUSTEN, K.C.B., D.C.L., F.R.S.

In Large 8vo, Handsome Cloth. With Illustrations.

INTRODUCTION to the STUDY of METALLURGY.

By the EDITOR. FIFTH EDITION. (See p. 63.)

GOLD (The Metallurgy of). By THOS. KIRKE ROSE, D.Sc., Assoc. R.S.M., F.I.C., Chemist and Assayer of the Royal Mint. FOURTH EDITION. 21s. (See p. 63.)

LEAD AND SILVER (The Metallurgy of). By H. F. COLLINS, Assoc. R.S.M., M.Inst.M.M. Part I., Lead, 16s; Part II., Silver, 16s. (See p. 64.)

IRON (The Metallurgy of). By T. TURNER, A.R.S.M., F.I.C., F.C.S. SECOND EDITION, Revised. 16s. (See p. 65.)

STEEL (The Metallurgy of). By F. W. HARBORD, Assoc. R.S.M., F.I.C., and J. W. HALL, A.M.Inst., C.E. (See p. 65.) *[Ready shortly.]*

Will be Published at Short Intervals.

METALLURGICAL MACHINERY: the Application of Engineering to Metallurgical Problems. By HENRY CHARLES JENKINS, Wh.Sc., Assoc. R.S.M., Assoc. M.Inst. C.E., of the Royal College of Science.

ALLOYS. By the EDITOR.

. Other Volumes in Preparation.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

GRIFFIN'S METALLURGICAL SERIES.

FIFTH EDITION, thoroughly Revised and considerably Enlarged. Large 8vo, with numerous Illustrations and Micro-Photographic Plates of different varieties of Steel. 18s.

An Introduction to the Study of
METALLURGY.

BY

Sir W. ROBERTS-AUSTEN, K.C.B., D.C.L., F.R.S., A.R.S.M.,
Late Chemist and Assayer of the Royal Mint, and Professor of Metallurgy
in the Royal College of Science.

GENERAL CONTENTS.—The Relation of Metallurgy to Chemistry.—Physical Properties of Metals.—Alloys.—The Thermal Treatment of Metals.—Fuel and Thermal Measurements.—Materials and Products of Metallurgical Processes.—Furnaces.—Means of Supplying Air to Furnaces.—Thermo-Chemistry.—Typical Metallurgical Processes.—The Micro-Structure of Metals and Alloys.—Economic Considerations.

"No English text-book at all approaches this in the COMPLETENESS with which the most modern views on the subject are dealt with. Professor Austen's volume will be INVALUABLE, not only to the student, but also to those whose knowledge of the art is far advanced."—*Chemical News*.

FOURTH EDITION, Revised, Considerably Enlarged, and in part Re-written.
Including the most recent Improvements in the Cyanide Process.
With Frontispiece and numerous Illustrations. 21s.

THE METALLURGY OF GOLD.

BY

T. KIRKE ROSE, D.Sc.Lond., Assoc.R.S.M.,

Chemist and Assayer of the Royal Mint.

GENERAL CONTENTS.—The Properties of Gold and its Alloys.—Chemistry of Gold.—Mode of Occurrence and Distribution.—Placer Mining.—Shallow Deposits.—Deep Places Mining.—Quartz Crushing in the Stamp Battery.—Amalgamation.—Other Forms of Crushing and Amalgamating.—Concentration.—Stamp Battery Practice.—Chlorination: The Preparation of Ore.—The Vat Process.—The Barrel Process.—Chlorination Practice in Particular Mills.—The Cyanide Process.—Chemistry of the Process.—Pyritic Smelting.—The Refining and Parting of Gold Bullion.—The Assay of Gold Ores.—The Assay of Bullion.—Economic Considerations.—Bibliography.

"A COMPREHENSIVE PRACTICAL TREATISE on this important subject."—*The Times*.

"The MOST COMPLETE description of the CHLORINATION PROCESS which has yet been published."—*Mining Journal*.

"Adapted for all who are interested in the Gold Mining Industry, being free from technicalities as far as possible, but is more particularly of value to those engaged in the industry."—*Cape Times*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, 8TRAND.

GRIFFIN'S METALLURGICAL SERIES.

EDITED BY SIR W. ROBERTS-AUSTEN, K.C.B., F.R.S., D.C.L.

In Large 8vo. Handsome Cloth. With Illustrations.

In Two Volumes, Each Complete in Itself and Sold Separately.

THE METALLURGY OF LEAD AND SILVER.

By H. F. COLLINS, Assoc.R.S.M., M.INST.M.M.

Part I.—LEAD:

A Complete and Exhaustive Treatise on the Manufacture of Lead, with Sections on Smelting and Desilverisation, and Chapters on the Assay and Analysis of the Materials involved. Price 16s.

SUMMARY OF CONTENTS.—Sampling and Assaying Lead and Silver.—Properties and Compounds of Lead.—Lead Ores.—Lead Smelting.—Reverberatories.—Lead Smelting in Hearths.—The Roasting of Lead Ores.—Blast Furnace Smelting; Principles, Practice, and Examples; Products.—Flue Dust, its Composition, Collection and Treatment.—Costs and Losses, Purchase of Ores.—Treatment of Zinc, Lead Sulphides, Desilverisation, Softening and Refining.—The Pattinson Process.—The Parkes Process.—Capellation and Refining, &c., &c.

"A THOROUGHLY SOUND and useful digest. May with EVERY CONFIDENCE be recommended."—*Mining Journal*.

Part II.—SILVER.

Comprising Details regarding the Sources and Treatment of Silver Ores, together with Descriptions of Plant, Machinery, and Processes of Manufacture, Refining of Bullion, Cost of Working, &c. Price 16s.

SUMMARY OF CONTENTS.—Properties of Silver and its Principal Compounds.—Silver Ores.—The Patio Process.—The Kazo, Fondon, Kröhnke, and Tina Processes.—The Pan Process.—Roast Amalgamation.—Treatment of Tailings and Concentration.—Retorting, Melting, and Assaying.—Chloridising—Roasting.—The Augustin, Claudet, and Ziersvogel Processes.—The Hypo-Sulphite Leaching Process.—Refining.—Matte Smelting.—Pyritic Smelting.—Matte Smelting in Reverberatories.—Silver-Copper Smelting and Refining.—INDEX.

"The author has focussed a LARGE AMOUNT OF VALUABLE INFORMATION into a convenient form. . . . The author has evidently considerable practical experience, and describes the various processes clearly and well."—*Mining Journal*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

GRIFFIN'S METALLURGICAL SERIES.

SECOND EDITION, Revised. Price 16s.

THE METALLURGY OF IRON.

BY **THOMAS TURNER, Assoc.R.S.M., F.I.C.,**

Professor of Metallurgy in the University of Birmingham.

**IN LARGE 8VO, HANDSOME CLOTH, WITH NUMEROUS ILLUSTRATIONS
(MANY FROM PHOTOGRAPHS).**

General Contents.—Early History of Iron.—Modern History of Iron.—The Age of Steel.—Chief Iron Ores.—Preparation of Iron Ores.—The Blast Furnace.—The Air used in the Blast Furnace.—Reactions of the Blast Furnace.—The Fuel used in the Blast Furnace.—Slags and Fluxes of Iron Smelting.—Properties of Cast Iron.—Foundry Practice.—Wrought Iron.—Indirect Production of Wrought Iron.—The Puddling Process.—Further Treatment of Wrought Iron.—Corrosion of Iron and Steel.

"A MOST VALUABLE SUMMARY of knowledge relating to every method and stage in the manufacture of cast and wrought iron . . . rich in chemical details. . . . EXHAUSTIVE and THOROUGHLY UP-TO-DATE."—*Bulletin of the American Iron and Steel Association.*

"This is a DELIGHTFUL BOOK, giving, as it does, reliable information on a subject becoming every day more elaborate."—*Colliery Guardian.*

"A THOROUGHLY USEFUL BOOK, which brings the subject UP TO DATE. OF GREAT VALUE to those engaged in the iron industry."—*Mining Journal.*

IN ACTIVE PREPARATION.

New Volume of the "Metallurgical Series."

THE METALLURGY OF STEEL.

BY **F. W. HARBORD, Assoc.R.S.M., F.I.C.,**

*Consulting Metallurgist and Analytical Chemist to the Indian Government,
Royal Indian Engineering College, Coopers Hill.*

WITH NEARLY 350 ILLUSTRATIONS COMPRISING NUMEROUS DIAGRAMS
OF PLANT AND MACHINERY, REDUCED FROM WORKING DRAWINGS,
AND A SECTION ON MILL PRACTICE

BY **J. W. HALL, A.M.Inst.C.E.**

IN PREPARATION.

METALLURGICAL MACHINERY:

The Application of Engineering to Metallurgical Problems.

BY **HENRY CHARLES JENKINS,**

Wh.Sc., Assoc.R.S.M., Assoc.M.Inst.C.E.

* * For Details of WORKS ON MINING, see pages 55-59.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

A TEXT-BOOK OF ASSAYING :

For the use of Students, Mine Managers, Assayers, &c.

By J. J. BERINGER, F.I.C., F.C.S.,

Public Analyst for, and Lecturer to the Mining Association of, Cornwall.

AND C. BERINGER, F.C.S.,

Late Chief Assayer to the Rio Tinto Copper Company, London.

With numerous Tables and Illustrations. Crown 8vo. Cloth, 10s. 6d.
EIGHTH EDITION.

GENERAL CONTENTS. — PART I. — INTRODUCTORY; MANIPULATION: Sampling; Drying; Calculation of Results—Laboratory-books and Reports. METHODS: Dry Gravimetric; Wet Gravimetric—Volumetric Assays: Titrometric, Colorimetric, Gasometric—Weighing and Measuring—Reagents—Formule, Equations, &c.—Specific Gravity.

PART II.—METALS: Detection and Assay of Silver, Gold, Platinum, Mercury, Copper, Lead, Thallium, Bismuth, Antimony, Iron, Nickel, Cobalt, Zinc, Cadmium, Tin, Tungsten, Titanium, Manganese, Chromium, &c.—Earths, Alkalies.

PART III.—NON-METALS: Oxygen and Oxides; The Halogens—Sulphur and Sulphates—Arsenic, Phosphorus, Nitrogen—Silicon, Carbon, Boron—Useful Tables.

"A REALLY MERITORIOUS WORK, that may be safely depended upon either for systematic instruction or for reference."—*Nature*.

"This work is one of the BEST of its kind. . . . Contains all the information that the Assayer will find necessary in the examination of minerals."—*Engineer*.

THIRD EDITION, Revised. Handsome Cloth. With Numerous
Illustrations. 6s.

A TEXT-BOOK OF ELEMENTARY METALLURGY.

Including the Author's PRACTICAL LABORATORY COURSE.

By A. HUMBOLDT SEXTON, F.I.C., F.C.S.,
Professor of Metallurgy in the Glasgow and West of Scotland Technical College.

GENERAL CONTENTS.—Introduction—Properties of the Metals—Combustion—Fuels—Refractory Materials—Furnaces—Occurrence of the Metals in Nature—Preparation of the Ore for the Smelter—Metallurgical Processes—Iron: Preparation of Pig Iron—Malleable Iron—Steel—Mild Steel—Copper—Lead—Zinc and Tin—Silver—Gold—Mercury—Alloys—Applications of ELECTRICITY to Metallurgy—LABORATORY COURSE WITH NUMEROUS PRACTICAL EXERCISES.

"Just the kind of work for Students COMMENCING the study of Metallurgy, or for ENGINEERING Students requiring a GENERAL KNOWLEDGE of it, or for ENGINEERS in practice who like a HANDY WORK OF REFERENCE. To all three classes we HEARTILY commend the work."—*Practical Engineer*.

"EXCELLENTLY got-up and WELL-ARRANGED. . . . Iron and copper well explained by EXCELLENT diagrams showing the stages of the process from start to finish. . . . The most NOVEL chapter is that on the many changes wrought in Metallurgical Methods by ELECTRICITY."—*Chemical Trade Journal*.

"Possesses the GREAT ADVANTAGE of giving a COURSE OF PRACTICAL WORK."—*Mining Journal*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

In Large Crown 8vo. With Numerous Illustrations. 8s. 6d.

The Art of the Goldsmith and Jeweller

A Manual on the Manipulation of Gold in the Various Processes of Goldsmith's Work, and the Manufacture of Personal Ornaments. For Students and Practical Men.

BY THOS. B. WIGLEY,

Headmaster of the Jewellers and Silversmiths' Association Technical School, Birmingham.

ASSISTED BY

J. H. STANSBIE, B.Sc. (LOND.), F.I.C.,
Lecturer at the Birmingham Municipal Technical School.

General Contents.—Introduction.—The Ancient Goldsmith's Art.—The Metallurgy of Gold.—Prices of Gold, Silver, &c.—Preparation of Alloys.—Melting of Gold.—Rolling and Slitting of Gold.—The Workshop and Tools.—Filigree Wire Drawing.—Manufacture of Personal Ornaments.—Finger Rings.—Mounting and Setting.—Mayoral Chains and Civic Insignia.—Antique Jewellery and its Revival.—Etruscan Work.—Manufacture of Gold Chains.—PRECIOUS STONES.—Cutting Diamonds and other Precious Gems.—Polishing and Finishing.—Chasing, Embossing, and Repoussé Work.—The Colouring and Finishing of Articles of Jewellery.—Enamelling: its History, Processes, and Applicability.—Heraldic Distinctions and Armorial Bearings.—Engraving: its Origin, History, and Processes.—Moulding and Casting of Ornaments, &c.—Fluxes, &c.—Recovery of the Precious Metals from the Waste Products.—Refining Semei and Assaying Semei Bars.—Gilding and Electro Deposition.—Hall-Marking Gold and Silver Plate.—Miscellaneous Useful Information.—Appendix: Technological Examinations.

In Large 8vo. Handsome Cloth. Price 4s.

TABLES FOR QUANTITATIVE METALLURGICAL ANALYSIS. FOR LABORATORY USE.

BY J. JAMES MORGAN, F.C.S.,

Member Soc. Chem. Industry, Member Cleveland Institute of Engineers.

SUMMARY OF CONTENTS.—Iron Ores.—Steel.—Limestone, &c.—Boiler Incrustations, Clays, and Fire-bricks.—Blast Furnace Slag, &c.—Coal, Coke, and Patent Fuel.—Water.—Gases.—Copper.—Zinc.—Lead.—Alloys.—White Lead.—Atomic Weights.—Factors.—Reagents, &c.

. The above work contains several NOVEL FEATURES, notably the extension to quantitative analysis, of the PRINCIPLES OF 'GROUP' SEPARATIONS, hitherto chiefly confined to Qualitative work, and will be found to FACILITATE GREATLY the operations of CHEMISTS, ANALYSTS, and others.—*Publisher's Note.*

"The Author may be CONGRATULATED on the way his work has been carried out."—*The Engineer.*

"Will COMMEND ITSELF highly in Laboratory Practice. Its CLEARNESS and PRECISION mark the book out as a highly useful one."—*Mining Journal.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

SECOND EDITION, Revised, Enlarged, and in part Re-written.
With Additional Sections on MODERN THEORIES OF ELECTROLYSIS
Costs, &c. Price 10s. 6d.

A TREATISE ON ELECTRO-METALLURGY:

Embracing the Application of Electrolysis to the Plating, Depositing,
Smelting, and Refining of various Metals, and to the Repro-
duction of Printing Surfaces and Art-Work, &c.

BY
WALTER G. McMILLAN, F.I.C., F.C.S.,
*Secretary to the Institution of Electrical Engineers; late Lecturer in Metallurgy
at Mason College, Birmingham.*

With numerous Illustrations. Large Crown 8vo. Cloth.

"This excellent treatise, . . . one of the BEST and MOST COMPLETE
manuals hitherto published on Electro-Metallurgy."—*Electrical Review*.

"This work will be a STANDARD."—*Jeweller*.

"Any metallurgical process which REDUCES the cost of production
must of necessity prove of great commercial importance. . . . We
recommend this manual to ALL who are interested in the PRACTICAL
APPLICATION of electrolytic processes."—*Nature*.

In large 8vo. With Numerous Illustrations and Three Folding-Plates.
Price 21s.

ELECTRIC SMELTING & REFINING:

A Practical Manual of the Extraction and Treatment
of Metals by Electrical Methods.

Being the "ELEKTRO-METALLURGIE" of DR. W. BORCHERS.

Translated from the Second Edition by WALTER G. McMILLAN,
F.I.C., F.C.S.

CONTENTS.

PART I.—ALKALIES AND ALKALINE EARTH METALS: Magnesium,
Lithium, Beryllium, Sodium, Potassium, Calcium, Strontium, Barium,
the Carbides of the Alkaline Earth Metals.

PART II.—THE EARTH METALS: Aluminium, Cerium, Lanthanum,
Didymium.

PART III.—THE HEAVY METALS: Copper, Silver, Gold, Zinc and Cad-
mium, Mercury, Tin, Lead, Bismuth, Antimony, Chromium, Molybdenum,
Tungsten, Uranium, Manganese, Iron, Nickel, and Cobalt, the Platinum
Group.

'COMPREHENSIVE and AUTHORITATIVE . . . not only FULL of VALUABLE INFOR-
MATION, but gives evidence of a THOROUGH INSIGHT into the technical VALUE and
POSSIBILITIES of all the methods discussed.'—*The Electrician*.

'DR. BORCHERS' WELL-KNOWN WORK . . . must of NECESSITY BE ACQUIRED by
every one interested in the subject. EXCELLENTLY put into English with additional
matter by Mr. McMILLAN.'—*Nature*.

"Will be of GREAT SERVICE to the practical man and the Student."—*Electric Smelting*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

§9. Griffin's Chemical and Technological Publications.

For Metallurgy and Electro-Metallurgy, see previous Section.

| | PAGE |
|--|--|
| Inorganic Chemistry, . . . | PROFS. DUPRÉ AND HARR, 70 |
| Quantitative Analysis, . . | PROF. HUMBOLDT SEXTON, 70 |
| Qualitative " " . . . | " " " 70 |
| Chemistry for Engineers, . . | BLOUNT AND BLOXAM, . 71 |
| " " "Manufacturers, . . . | " " " 71 |
| Foods, Analysis of, . . . | A. WYNTER BLYTH, . 72 |
| Poisons, Detection of, . . . | " " " 72 |
| Tables for Chemists and Manufacturers, . . . | PROF. CASTELL-EVANS, . 79 |
| Agricultural Chemistry, . . | PROF. J. M. H. MUNRO, 75 |
| Dairy Chemistry, . . . | H. D. RICHMOND, . 73 |
| Flesh Foods, . . . | C. A. MITCHELL, . 74 |
| Practical Sanitation, . . . | DR. G. REID, . . 78 |
| Sanitary Engineering, . . . | F. WOOD, . . . 78 |
| Technical Mycology (The Fermentation Industries) } | LAFAR AND SALTER, . 73 |
| Ferments, | C. OPPENHEIMER, . 74 |
| Brewing, | DR. W. J. SYKES, . 75 |
| Sewage Disposal, | SANTO CRIMP, . . 76 |
| Trades' Waste, | W. NAYLOR, . . 77 |
| Cements, | G. R. REDGRAVE, . 76 |
| Road Making, | THOS. AITKEN, . . 79 |
| Gas Manufacture, | W. ATKINSON BUTTERFIELD, 77 |
| Petroleum, | REDWOOD AND HOLLOWAY, 61 |
| —(Handbook), | THOMSON AND REDWOOD, 61 |
| Oils, Soaps, Candles, . . . | DR. ALDER WRIGHT, . 81 |
| Lubrication and Lubricants, | ARCHBUTT AND DEELEY, 32 |
| India Rubber, | DR. CARL O. WEBER, . 81 |
| Painters' Colours, Oils, and Varnishes, | G. H. HURST, . . 80 |
| Painters' Laboratory Guide, | " " " 80 |
| Painting and Decorating, | W. J. PEARCE, . . 80 |
| Photography, | A. BROTHERS, . . 21 |
| Dyeing, | KNECHT AND RAWSON, . 82 |
| Dictionary of Dyes, | RAWSON, GARDNER, AND LAYCOCK, . . . 82 |
| Textile Printing, | SEYMOUR ROTHWELL, . 83 |
| Textile Fibres of Commerce, | W. I. HANNAN, . . 83 |
| Dyeing and Cleaning, | G. H. HURST, . . 84 |
| Bleaching and Calico-Printing, | GEO. DUERE, . . 84 |

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

A SHORT MANUAL OF INORGANIC CHEMISTRY.

BY

A. DUPRÉ, Ph.D., F.R.S.,

AND

WILSON HAKE, Ph.D., F.I.C., F.C.S.,
Of the Westminster Hospital Medical School.

THIRD EDITION, Revised, Enlarged, and brought up-to-date. Price 9s. net.

"A well-written, clear and accurate Elementary Manual of Inorganic Chemistry. . . . We agree heartily with the system adopted by Drs. Dupré and Hake. WILL MAKE EXPERIMENTAL WORK TREASURABLE BECAUSE INTELLIGIBLE."—*Saturday Review*.

"There is no question that, given the PERFECT GROUNDING of the Student in his Science, the remainder comes afterwards to him in a manner much more simple and easily acquired. The work is AN EXAMPLE OF THE ADVANTAGES OF THE SYSTEMATIC TREATMENT of a Science over the fragmentary style so generally followed. BY A LONG WAY THE BEST of the small Manuals for Students."—*Analyst*.

LABORATORY HANDBOOKS BY A. HUMBOLDT SEXTON,
Professor of Metallurgy in the Glasgow and West of Scotland Technical College.

OUTLINES OF QUANTITATIVE ANALYSIS. FOR THE USE OF STUDENTS.

With Illustrations. FOURTH EDITION. Crown 8vo, Cloth, 3s.

"A COMPACT LABORATORY GUIDE for beginners was wanted, and the want has been WELL SUPPLIED. . . . A good and useful book."—*Lancet*.

OUTLINES OF QUALITATIVE ANALYSIS. FOR THE USE OF STUDENTS.

With Illustrations. FOURTH EDITION, Revised. Crown 8vo, Cloth, 3s. 6d.

"The work of a thoroughly practical chemist."—*British Medical Journal*.
"Compiled with great care, and will supply a want."—*Journal of Education*.

ELEMENTARY METALLURGY:

Including the Author's Practical Laboratory Course. With many
Illustrations. [See p. 66.]

THIRD EDITION, Revised. Crown 8vo. Cloth, 6s.

"Just the kind of work for students commencing the study of metallurgy."—*Practical Engineer*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

CHEMISTRY FOR ENGINEERS AND MANUFACTURERS.

A PRACTICAL TEXT-BOOK.

BY

BERTRAM BLOUNT, AND

A. G. BLOXAM,

F.I.C., F.C.S., Assoc.Inst.C.E.,
Consulting Chemist to the Crown Agents for
the Colonies.F.I.C., F.C.S.,
Consulting Chemist, Head of the Chemistry
Department, Goldsmiths' Inst.,
New Cross.

In Two Vols., Large 8vo. With Illustrations. Sold Separately.

"The authors have succeeded beyond all expectations, and have produced a work which should give **POWER** to the Engineer and Manufacturer."—*The Times*.

VOLUME I. Price 10s. 6d.

CHEMISTRY OF ENGINEERING, BUILDING, AND METALLURGY.

General Contents.—INTRODUCTION—Chemistry of the Chief Materials of Construction—Sources of Energy—Chemistry of Steam-raising—Chemistry of Lubrication and Lubricants—Metallurgical Processes used in the Winning and Manufacture of Metals.

"PRACTICAL THROUGHOUT . . . an ADMIRABLE TEXT-BOOK, useful not only to Students, but to ENGINEERS and MANAGERS of WORKS in PREVENTING WASTE and IMPROVING PROCESSES."—*Scotsman*.

"EMINENTLY PRACTICAL."—*Glasgow Herald*.

"A book worthy of HIGH RANK . . . its merit is great . . . treatment of the subject of GASEOUS FUEL particularly good. . . . WATER GAS and the production clearly worked out. Altogether a most creditable production. We WARMLY RECOMMEND IT, and look forward with keen interest to the appearance of Vol. II."—*Journal of Gas Lighting*.

VOLUME II. Price 16s.

THE CHEMISTRY OF MANUFACTURING PROCESSES.

General Contents.—Sulphuric Acid Manufacture—Manufacture of Alkali, &c.—Destructive Distillation—Artificial Manure Manufacture—Petroleum—Lime and Cement—Clay Industries and Glass—Sugar and Starch—Brewing and Distilling—Oils, Resins, and Varnishes—Soap and Candles—Textiles and Bleaching—Colouring Matters, Dyeing, and Printing—Paper and Pasteboard—Pigments and Paints—Leather, Glue, and Size—Explosives and Matches—Minor Chemical Manufactures.

"Certainly a GOOD and USEFUL BOOK, constituting a PRACTICAL GUIDE for students by affording a clear conception of the numerous processes as a whole."—*Chemical Trade Journal*.

"We CONFIDENTLY RECOMMEND this volume as a PRACTICAL, and not overloaded, TEXT-BOOK, of GREAT VALUE to students."—*The Builder*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

WORKS BY A. WYNTER BLYTH, M.R.C.S., F.C.S.,
Barrister-at-Law, Public Analyst for the County of Devon, and Medical Officer of Health for
St. Marylebone.

FOODS: THEIR COMPOSITION AND ANALYSIS.

In Demy 8vo, with Elaborate Tables, Diagrams, and Plates. Handsome
Cloth. FIFTH EDITION, Thoroughly Revised,
Enlarged, and Re-written. [AT PRESS.

GENERAL CONTENTS.

History of Adulteration—Legislation, Past and Present—Apparatus
useful to the Food-Analyst—"Ash"—Sugar—Confectionery—Honey—
Treacle—Jams and Preserved Fruits—Starches—Wheaten-Flour—Bread
—Oats—Barley—Rye—Rice—Maize—Millet—Potato—Peas—Chinese
Peas—Lentils—Beans—MILK—Cream—Butter—Oleo-Margarine—
Butterine—Cheese—Lard—Tea—Coffee—Cocoa and Chocolate—Alcohol—
Brandy—Rum—Whisky—Gin—Arrack—Liqueurs—Absinthe—Principles
of Fermentation—Yeast—Beer—Wine—Vinegar—Lemon and Lime
Juice—Mustard—Pepper—Sweet and Bitter Almond—Annatto—Olive
Oil—WATER—Standard Solutions and Reagents. *Appendix: Text of
English and American Adulteration Acts.*

PRESS NOTICES OF THE FOURTH EDITION.

"Simply **INDISPENSABLE** in the Analyst's laboratory."—*The Lancet*.
"THE **STANDARD WORK** on the subject. . . . Every chapter and every page gives
abundant proof of the strict revision to which the work has been subjected. . . . The
section on **MILK** is, we believe, the most exhaustive study of the subject extant. . . . AN
INDISPENSABLE MANUAL for Analysts and Medical Officers of Health."—*Public Health*.
"A new edition of Mr. Wynter Blyth's **Standard work**, **REVISIONED WITH ALL THE LATEST
DISCOVERIES AND IMPROVEMENTS**, will be accepted as a boon."—*Chemical News*.

POISONS: THEIR EFFECTS AND DETECTION.

THIRD EDITION. In Large 8vo, Cloth, with Tables and Illustrations.
Price 21s.

GENERAL CONTENTS.

I.—Historical Introduction. II.—Classification—Statistics—Connection
between Toxic Action and Chemical Composition—Life Tests—General
Method of Procedure—The Spectroscope—Examination of Blood and Blood
Stains. III.—Poisonous Gases. IV.—Acids and Alkalies. V.—More
or less Volatile Poisonous Substances. VI.—Alkaloids and Poisonous
Vegetable Principles. VII.—Poisons derived from Living or Dead Animal
Substances. VIII.—The Oxalic Acid Group. IX.—Inorganic Poisons.
Appendix: Treatment, by Antidotes or otherwise, of Cases of Poisoning.

"Undoubtedly THE MOST COMPLETE WORK on Toxicology in our language."—*The Analyst* (on
the Third Edition).

"As a PRACTICAL GUIDE, we know NO BETTER work."—*The Lancet* (on the Third Edition).

"In the **THIRD EDITION**, Enlarged and partly Re-written, NEW ANALYTICAL METHODS have
been introduced, and the CADAVERIC ALKALOIDS, or PTOMAINS, bodies playing so great a part in
Food-poisoning and in the Manifestations of Disease, have received special attention.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

With Numerous Tables, and 22 Illustrations. 16s.

DAIRY CHEMISTRY

FOR DAIRY MANAGERS, CHEMISTS, AND ANALYSTS

A Practical Handbook for Dairy Chemists and others
having Control of Dairies.

By H. DROOP RICHMOND, F.C.S.,

CHEMIST TO THE AYLSBURY DAIRY COMPANY.

Contents.—I. Introductory.—The Constituents of Milk. II. The Analysis of Milk. III. Normal Milk: its Adulterations and Alterations, and their Detection. IV. The Chemical Control of the Dairy. V. Biological and Sanitary Matters. VI. Butter. VII. Other Milk Products. VIII. The Milk of Mammals other than the Cow.—Appendices.—Tables.—Index.

"... In our opinion the book is the BEST CONTRIBUTION ON THE SUBJECT THAT HAS YET APPEARED in the English language."—*Lancet*.

"The author has succeeded in putting before the reader a complete book on Dairy Chemistry. It forms a COMPLETE *résumé* OF THEORETICAL AND PRACTICAL KNOWLEDGE, written in easy, intelligible language."—*The Analyst*.

In Large 8vo. Handsome Cloth. With numerous Illustrations.

Vol. I. Complete in Itself. Price 15s.

[Part I., Vol. II., at Press.

TECHNICAL MYCOLOGY:

THE UTILISATION OF MICRO-ORGANISMS IN THE ARTS AND MANUFACTURES.

*A Practical Handbook on Fermentation and Fermentative Processes for the Use of
Brewers and Distillers, Analysts, Technical and Agricultural Chemists,
and all interested in the Industries dependent on Fermentation.*

By DR. FRANZ LAFAR,

Professor of Fermentation-Physiology and Bacteriology in the Technical
High School, Vienna.

With an Introduction by DR. EMIL CHR. HANSEN, Principal of the
Carlsberg Laboratory, Copenhagen.

TRANSLATED BY CHARLES T. C. SALTER.

"The first work of the kind which can lay claim to completeness in the treatment of a fascinating subject. The plan is admirable, the classification simple, the style is good, and the tendency of the whole volume is to convey sure information to the reader."—*Lancet*.

"We cannot sufficiently praise Dr. Lafar's work nor that of his admirable translator. No brewer with a love for his calling can allow such a book to be absent from his library."—*Brewer's Journal, New York*.

"The publishers trust that before long they will be able to present English readers with the whole of the second volume, arrangements having been concluded whereby, upon its appearance in Germany, the English translation will be at once put in hand. This is now being done with Part I., which will be issued shortly, and which will be followed by the two final parts.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

Crown 8vo, Handsome Cloth. Fully Illustrated. 10s. 6d.

FLESH FOODS:

With Methods for their Chemical, Microscopical, and Bacteriological Examination.

A Practical Handbook for Medical Men, Analysts, Inspectors and others.

By C. AINSWORTH MITCHELL, B.A.(OXON),

Fellow of the Institute of Chemistry; Member of Council, Society of Public Analysts.

With Numerous Tables, Illustrations, and a Coloured Plate.

CONTENTS.—Structure and Chemical Composition of Muscular Fibre.—of Connective Tissue, and Blood.—The Flesh of Different Animals.—The Examination of Flesh.—Methods of Examining Animal Fat.—The Preservation of Flesh.—Composition and Analysis of Sausages.—Proteids of Flesh.—Meat Extracts and Flesh Peptones.—The Cooking of Flesh.—Poisonous Flesh.—The Animal Parasites of Flesh.—The Bacteriological Examination of Flesh.—The Extraction and Separation of Potatoes.—INDEX.

. This work is a complete compendium of the CHEMISTRY OF ANIMAL TISSUES. It contains directions for the detection of morbid conditions, putrefactive changes, and poisonous or injurious constituents, together with an account of their causes and effects.—*Publishers' Note.*

"A compilation which will be most useful for the class for whom it is intended."—*Athenaeum.*

"A book which NO ONE whose duties involve considerations of food supply CAN AFFORD TO BE WITHOUT."—*Municipal Journal.*

In Crown 8vo, Handsome Cloth. Price 7s. 6d. net.

FERMENTS

AND THEIR ACTIONS.

A Text-book on the Chemistry and Physics of Fermentative Changes.

By CARL OPPENHEIMER, PH.D., M.D.,

Of the Physiological Institute at Erlangen.

TRANSLATED FROM THE GERMAN BY

C. AINSWORTH MITCHELL, B.A., F.I.C., F.C.S.

ABRIDGED CONTENTS.—I. Introduction.—II. Definition of a Ferment.—III. Chemical Nature of Ferments.—IV. Influence of External Factors.—V. Mode of Action.—VI. Physiological Action of Ferments.—VII. Secretion of Ferments.—VIII. Importance of Ferments to Vital Action.—IX. Proteolytic Ferments.—X. Trypsin.—XI. Bacteriolytic and Hemolytic Ferments.—XII. Vegetable Ferments.—XIII. Coagulating Ferments.—XIV. Saccharifying Ferments.—XV. Animal Diastases.—XVI. Polysaccharides.—XVII. Enzymes.—XVIII. Ferments which decompose Glucosides.—XIX. Hydrolytic Ferments.—XX. Lactic Acid Fermentation.—XXI. Alcoholic Fermentation.—XXII. Biology of Alcoholic Fermentation.—XXIII. Oxydases.—XXIV. Oxidising Fermentation.—Bibliography.—INDEX.

The present Translation embodies Notes and Additions to the Work made by the Author subsequent to its Publication in Germany.

"Will be a valuable addition to the library of every institution where the work touches the vast series of phenomena called fermentations, whether in pathology, commerce, or scientific research."—*The Athenaeum.*

"Such a veritable *multum in parvo* has never yet appeared. The author has set himself the task of writing a work on Ferments that should embrace human erudition on the subject."—*Brewers' Journal.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

SECOND EDITION, Revised. In Large 8vo. Handsome Cloth.
Price 21s.

THE PRINCIPLES AND PRACTICE OF BREWING.

FOR THE USE OF STUDENTS AND PRACTICAL MEN.

BY

WALTER J. SYKES, M.D., D.P.H., F.I.C.,

EDITOR OF "THE ANALYST."

With Plate and Illustrations.

ABSTRACT OF CONTENTS.

- | | |
|--|------------------------|
| I. Physical Principles involved in Brewing Operations. | III. Water. |
| Chemistry with special reference to the materials used in Brewing. | Barley and Malting. |
| II. The Microscope. | Brewery Plant. |
| Vegetable Biology. | Brewing. |
| | Beer and its Diseases. |
| | Appendices. |
| | Index. |

"A volume of Brewing Science, which has long been awaited. . . . We consider it one of the most complete in contents and novel in arrangement that has yet been published. . . . Will command a large sale."—*The Brewers' Journal*.

"The appearance of a work such as this serves to remind us of the enormously rapid advances made in our knowledge of the Scientific Principles underlying the Brewing Processes. . . . Dr. Sykes' work will undoubtedly be of the greatest assistance, not merely to Brewers, but to all Chemists and Biologists interested in the problems which the Fermentation industries present."—*The Analyst*.

"The publication of Dr. Sykes' MASTERLY TREATISE on the art of Brewing is quite an event in the Brewing World. . . . Deserves our warmest praise. . . . A better guide than Dr. Sykes could hardly be found."—*County Brewers' Gazette*.

In Large 8vo. Handsome Cloth.

AGRICULTURAL CHEMISTRY AND ANALYSIS:

A PRACTICAL HANDBOOK FOR THE USE OF AGRICULTURAL STUDENTS.

BY

J. M. H. MUNRO, D.Sc., F.I.C., F.C.S.,

Professor of Chemistry, Downton College of Agriculture.

[In Preparation.]

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

SECOND EDITION, REVISED AND ENLARGED.

With Tables, Illustrations in the Text, and 37 Lithographic Plates. Medium
8vo. Handsome Cloth. 30s.

SEWAGE DISPOSAL WORKS:

A Guide to the Construction of Works for the Prevention of the
Pollution by Sewage of Rivers and Estuaries.

By W. SANTO CRIMP, M. INST. C. E., F. G. S.,
Late Assistant-Engineer, London County Council.

PART I.—INTRODUCTORY. PART II.—SEWAGE DISPOSAL WORKS IN
OPERATION—THEIR CONSTRUCTION, MAINTENANCE, AND COST.

"* From the fact of the Author's having, for some years, had charge of the Main
Drainage Works of the Northern Section of the Metropolis, the chapter on LONDON will be
found to contain many important details which would not otherwise have been available.

"All persons interested in Sanitary Science owe a debt of gratitude to Mr. Crimp. . . .
His work will be especially useful to SANITARY AUTHORITIES and their advisers. . . .
ESSENTIALLY PRACTICAL AND USEFUL. . . . gives plans and descriptions of MANY OF THE
MOST IMPORTANT SEWAGE WORKS of England. . . . with very valuable information as to
the cost of construction and working of each. . . . The carefully-prepared drawings present
an easy comparison between the different systems."—*Lancet*.

"Probably the most COMPLETE AND BEST TREATISE on the subject which has appeared
in our language. . . . Will prove of the greatest use to all who have the problem of
Sewage Disposal to face."—*Edinburgh Medical Journal*.

In Crown 8vo, Extra. With Illustrations. 8s. 6d.

CALCAREOUS CEMENTS:

THEIR NATURE, PREPARATION, AND USES.

With some Remarks upon Cement Testing.

By GILBERT R. REDGRAVE, ASSOC. INST. C. E.,

Assistant Secretary for Technology, Board of Education, South Kensington.

GENERAL CONTENTS.—Introduction—Historical Review of the Cement
Industry—The Early Days of Portland Cement—Composition of Portland
Cement—PROCESSES OF MANUFACTURE—The Washmill and the Backs—
Flue and Chamber Drying Processes—Calcination of the Cement Mixture—
Grinding of the Cement—Composition of Mortar and Concrete—CEMENT
TESTING—CHEMICAL ANALYSIS of Portland Cement, Lime, and Raw
Materials—Employment of Slags for Cement Making—Scott's Cement,
Selenitic Cement, and Cements produced from Sewage Sludge and the
Refuse from Alkali Works—Plaster Cements—Specifications for Portland
Cement—Appendices (Gases Evolved from Cement Works, Effects of Sea-
water on Cement, Cost of Cement Manufacture, &c., &c.)

"A work calculated to be of GREAT and EXTENDED UTILITY."—*Chemical News*.

"INVALUABLE to the Student, Architect, and Engineer."—*Building News*.

"A work of the GREATEST INTEREST and USEFULNESS, which appears at a very critical
period of the Cement Trade."—*Brit. Trade Journal*.

"Will be useful to ALL interested in the MANUFACTURE, USE, and TESTING of Cements."—
Engineer.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

*Beautifully Illustrated, with Numerous Plates, Diagrams, and
Figures in the Text. 21s. net.*

TRADES' WASTE:

ITS TREATMENT AND UTILISATION.

With Special Reference to the Prevention of Rivers Pollution.

A Handbook for Borough Engineers, Surveyors, Architects'
and Analysts.

By W. NAYLOR, F.C.S., A.M. INST. C.E.,
Chief Inspector of Rivers, Ribble Joint Committee.

CONTENTS.—I. Introduction.—II. Chemical Engineering.—III.—Wool De-greasing and Grease Recovery.—IV. Textile Industries; Calico Bleaching and Dyeing.—V. Dyeing and Calico-Printing.—VI. Tanning and Fellmongery.—VII. Brewery and Distillery Waste.—VIII. Paper Mill Refuse.—IX. General Trades' Waste.—INDEX.

"Aims at setting forth the causes of rivers pollution, and the best known means of preventing such pollution economically. . . . An attempt has been made to point out the principles, characteristics, and advantages of the various systems of treatment."—*Author's Preface.*

"A contribution of considerable importance."—*The Lancet.*

"There is probably no person in England to-day better fitted to deal rationally with such a subject."—*British Sanitarian.*

"The work is thoroughly practical, and will serve as a handbook in the future for those who have to encounter the problems discussed."—*Chemical Trade Journal.*

SECOND EDITION, Revised and Enlarged, with New SECTION on
ACETYLENE. Fully Illustrated. 10s. 6d.

THE CHEMISTRY OF GAS MANUFACTURE.

*A Hand-Book on the Production, Purification, and Testing of Illuminating
Gas, and the Assay of the Bye-Products of Gas Manufacture.
For the Use of Students.*

BY

W. J. ATKINSON BUTTERFIELD, M.A., F.I.C., F.C.S.,
Formerly Head Chemist, Gas Works, Beckton, London, E.

GENERAL CONTENTS.—I. Raw Materials for Gas Manufacture.—II. Coal Gas.—III. Carburetted Water Gas.—IV. Oil Gas.—V. Enriching by Light Oils.—VI.—Final Details of Manufacture.—VII. Gas Analysis.—VIII. Photometry.—IX. Applications of Gas.—X. Bye-Products.—XI. Acetylene.—INDEX.

"The BEST WORK of its kind which we have ever had the pleasure of reviewing."—*Journal of Gas Lighting.*

"Amongst works not written in German, WE RECOMMEND BEFORE ALL OTHERS, BUTTERFIELD'S CHEMISTRY OF GAS MANUFACTURE."—*Chemiker Zeitung.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

TENTH EDITION, Revised. Price 6s.

PRACTICAL SANITATION: **A HAND-BOOK FOR SANITARY INSPECTORS AND OTHERS** **INTERESTED IN SANITATION.**

By **GEORGE REID, M.D., D.P.H.,***Fellow, Mem. Council, and Examiner, Sanitary Institute of Great Britain,
and Medical Officer to the Staffordshire County Council.*

With an Appendix on Sanitary Law.

By **HERBERT MANLEY, M.A., M.B., D.P.H.,***Medical Officer of Health for the County Borough of West Bromwich.*

GENERAL CONTENTS.—Introduction—Water Supply: Drinking Water, Pollution of Water—Ventilation and Warming—Principles of Sewage Removal—Details of Drainage; Refuse Removal and Disposal—Sanitary and Insanitary Work and Appliances—Details of Plumbers' Work—House Construction—Infection and Disinfection—Food, Inspection of; Characteristics of Good Meat; Meat, Milk, Fish, &c., unfit for Human Food—Appendix: Sanitary Law; Model Bye-Laws, &c.

"Dr. Reid's very useful Manual . . . ABOUNDS IN PRACTICAL DETAIL."
—*British Medical Journal*.

"A VERY USEFUL HANDBOOK, with a very useful Appendix. We recommend it not only to SANITARY INSPECTORS, but to HOUSEHOLDERS and ALL interested in Sanitary matters."—*Sanitary Record*.

COMPANION VOLUME TO REID'S SANITATION.

In Crown 8vo. Handsome Cloth. Profusely Illustrated. 8s. 6d. net.

Sanitary Engineering:

*A Practical Manual of Town Drainage and Sewage and Refuse Disposal.**For Sanitary Authorities, Engineers, Inspectors, Architects,
Contractors, and Students.*

BY

FRANCIS WOOD, A.M.INST.C.E., F.G.S.,*Borough Engineer and Surveyor, Fulham; late Borough Engineer, Bacup, Lancs.*

GENERAL CONTENTS.

Introduction.—Hydraulics.—Velocity of Water in Pipes.—Earth Pressures and Retaining Walls.—Powers.—House Drainage.—Land Drainage.—Sewers.—Separate System.—Sewage Pumping.—Sewer Ventilation.—Drainage Areas.—Sewers, Manholes, &c.—Trade Refuse.—Sewage Disposal Works.—BACTERIOLYSIS.—Sludge Disposal.—Construction and Cleansing of Sewers.—Refuse Disposal.—Chimneys and Foundations.

"The volume bristles with information which will be greedily read by those in need of assistance. The book is one that ought to be on the bookshelves of EVERY PRACTICAL ENGINEER."—*Sanitary Journal*.

"A VERITABLE POCKET COMPENDIUM of Sanitary Engineering. . . . A work which may, in many respects, be considered as COMPLETE . . . COMMENDABLY CAUTIOUS . . . INTERESTING . . . SUGGESTIVE."—*Public Health Engineer*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

VOL. I. NOW READY. IN HALF MOROCCO, 21s.

In Two Volumes, each complete in itself.

PHYSICO-CHEMICAL TABLES

FOR THE USE OF ANALYSTS, PHYSICISTS, CHEMICAL MANUFACTURERS, AND SCIENTIFIC CHEMISTS.

Volume I.—Chemical Engineering, Physical Chemistry. [*Just Out.*]

Volume II.—Chemical Physics, Pure and Analytical Chemistry.

By JOHN CASTELL-EVANS, F.I.C., F.C.S.,

Superintendent of the Chemical Laboratories, and Lecturer on Inorganic Chemistry and Metallurgy at the Finsbury Technical College.

The Tables may almost claim to be exhaustive, and embody and collate all the most recent data established by experimentalists at home and abroad. The volumes will be found invaluable to all engaged in research and experimental investigation in Chemistry and Physics.

The Work comprehends as far as possible ALL RULES AND TABLES required by the Analyst, Brewer, Distiller, Acid- and Alkali-Manufacturer, &c., &c.; and also the principal data in THERMO-CHEMISTRY, ELECTRO-CHEMISTRY, and the various branches of CHEMICAL PHYSICS. Every possible care has been taken to ensure perfect accuracy, and to include the results of the most recent investigations.

In Large 8vo. Handsome Cloth. Beautifully Illustrated. With Plates and Figures in the Text. 21s.

Road Making and Maintenance :

A PRACTICAL TREATISE FOR ENGINEERS, SURVEYORS, AND OTHERS.

WITH AN HISTORICAL SKETCH OF ANCIENT AND MODERN PRACTICE.

By THOS. AITKEN, ASSOC.M.INST.C.E.,

Member of the Association of Municipal and County Engineers; Member of the Sanitary Inst.; Surveyor to the County Council of Fife, Oupar Division.

WITH NUMEROUS PLATES, DIAGRAMS, AND ILLUSTRATIONS.

CONTENTS.—Historical Sketch.—Resistance of Traction.—Laying out New Roads.—Earthworks, Drainage, and Retaining Walls.—Road Materials, or Metal.—Quarrying.—Stone Breaking and Haulage.—Road-Rolling and Scarifying.—The Construction of New, and the Maintenance of existing Roads.—Carriage Ways and Foot Ways.

"The Literary style is EXCELLENT. . . . A COMPREHENSIVE and EXCELLENT Modern Book, an UP-TO-DATE work. . . . Should be on the reference shelf of every Municipal and County Engineer or Surveyor in the United Kingdom, and of every Colonial Engineer."—*The Surveyor*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

THIRD EDITION, Revised and Enlarged. With Illustrations. 12s. 6d.

Painters' Colours, Oils, & Varnishes: A PRACTICAL MANUAL.

BY GEORGE H. HURST, F.C.S.,

Member of the Society of Chemical Industry; Lecturer on the Technology of Paints' Colours, Oils, and Varnishes, the Municipal Technical School, Manchester.

GENERAL CONTENTS.—Introductory—THE COMPOSITION, MANUFACTURE, ASSAY, and ANALYSIS of PIGMENTS, White, Red, Yellow and Orange, Green, Blue, Brown, and Black—LAKES—Colour and Paint Machinery—Paint Vehicles (Oils, Turpentine, &c., &c.)—Driers—VARNISHES.

"A THOROUGHLY PRACTICAL book, . . . the ONLY English work that satisfactorily treats of the manufacture of oils, colours, and pigments."—*Chemical Trades' Journal*.

*. * FOR MR. HURST'S GARMENT DYEING AND CLEANING, see p. 84.

In Crown 8vo. Handsome Cloth. With Illustrations. 5s.

THE PAINTER'S LABORATORY GUIDE

A Student's Handbook of Paints, Colours, and Varnishes.

BY GEORGE H. HURST, F.C.S., M.S.C.I.

ABSTRACT OF CONTENTS.—Preparation of Pigment Colours.—Chemical Principles Involved.—Oils and Varnishes.—Properties of Oils and Varnishes.—Tests and Experiments.—Plants, Methods, and Machinery of the Paint and Varnish Manufactures.

This Work has been designed by the Author for the Laboratory of the Technical School, and of the Paint and Colour Works, and for all interested or engaged in these industries.

SECOND EDITION, Revised. In Crown 8vo. extra. With Numerous Illustrations and Plates (some in Colours), including Original Designs. 12s. 6d.

Painting and Decorating:

*A Complete Practical Manual for House
Painters and Decorators.*

BY WALTER JOHN PEARCE,

LECTURER AT THE MANCHESTER TECHNICAL SCHOOL FOR HOUSE-PAINTING AND DECORATING.

GENERAL CONTENTS.

Introduction—Workshop and Stores—Plant and Appliances—Brushes and Tools—Materials: Pigments, Driers, Painters' Oils—Wall Hangings—Paper Hanging—Colour Mixing—Distemping—Plain Painting—Staining—Varnish and Varnishing—Imitative Painting—Graining—Marbling—Gilding—Sign Writing and Lettering—Decoration: General Principles—Decoration in Distemper—Painted Decoration—Relievo Decoration—Colour—Measuring and Estimating—Coach-Painting—Ship-Painting.

"A THOROUGHLY USEFUL BOOK . . . GOOD, SOUND, PRACTICAL INFORMATION in a CLEAR and CONCISE FORM."—*Plumber and Decorator*.

"A THOROUGHLY GOOD and RELIABLE TEXT-BOOK. . . . So FULL and COMPLETE that it would be difficult to imagine how anything further could be added about the Painter's craft."—*Builders' Journal*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

JUST OUT. In Large 8vo. Handsome Cloth. With 4 Plates
and Several Illustrations. 16s. net.

THE CHEMISTRY OF INDIA RUBBER.

A Treatise on the Nature of India Rubber, its Chemical and
Physical Examination, and the Determination and
Valuation of India Rubber Substitutes.

Including the Outlines of a Theory on Vulcanisation.

BY

CARL OTTO WEBER, PH.D.

ABSTRACT OF CONTENTS.—Introduction.—The Chemistry of India Rubber.
—The Examination and Valuation of India Rubber.—Examination of India
Rubber Substitutes.—Inorganic Filling Materials.—Vulcanisers and Sulphur
Carriers.—India Rubber Solvents.—Colouring Matters and Pigment Colours.
—Constructive Components of India Rubber Articles.—Analysis of Manu-
factured India Rubber.—Sanitary Conditions in India Rubber Works.—
INDEX.

In Large 8vo. Handsome Cloth. With 144 Illustrations. 28s.

Fixed Oils, Fats, Butters, and Waxes:

THEIR PREPARATION AND PROPERTIES, AND MANUFACTURE THERE-
FROM OF CANDLES, SOAPS, AND OTHER PRODUCTS.

BY

C. R. ALDER WRIGHT, D.Sc., F.R.S.,

Late Lecturer on Chemistry, St. Mary's Hospital Medical School; Examiner in "Soap"
to the City and Guilds of London Institute.

"Dr. WRIGHT's work will be found ABSOLUTELY INDISPENSABLE by every Chemist.
Terms with information valuable alike to the Analyst and the Technical Chemist."—
The Analyst.

"Will rank as the STANDARD ENGLISH AUTHORITY ON OILS and FATS for many
years to come."—*Industries and Iron*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

{10. THE TEXTILE INDUSTRIES.

In Two Large Volumes, 920 pp., with a Supplementary Volume, containing Specimens of Dyed Fabrics. 45s.

A MANUAL OF DYEING: FOR THE USE OF PRACTICAL DYERS, MANUFACTURERS, STUDENTS, AND ALL INTERESTED IN THE ART OF DYEING.

BY

E. KNECHT, Ph.D., F.I.C.,
Head of the Chemistry and Dyeing Department of
the Technical School, Manchester; Editor of "The
Journal of the Society of Dyers and Colourists;"

CHR. RAWSON, F.I.C., F.C.S.,
Late Head of the Chemistry and Dyeing Department
of the Technical College, Bradford; Member of
Council of the Society of Dyers and Colourists;

And **RICHARD LOEWENTHAL, Ph.D.**

GENERAL CONTENTS.—Chemical Technology of the Textile Fabrics—
Water—Washing and Bleaching—Acids, Alkalies, Mordants—Natural
Colouring Matters—Artificial Organic Colouring Matters—Mineral Colours
—Machinery used in Dyeing—Tinctorial Properties of Colouring Matters—
Analysis and Valuation of Materials used in Dyeing, &c., &c.

"The MOST VALUABLE and USEFUL WORK on Dyeing that has yet appeared in the English
language. . . . Likely to be the STANDARD WORK of REFERENCE for years to come."—
Textile Mercury.

"This authoritative and exhaustive work . . . the MOST COMPLETE we have yet seen
on the subject."—*Textile Manufacturer.*

"The MOST EXHAUSTIVE and COMPLETE WORK on the subject extant."—*Textile Recorder.*

*Companion Volume to Knecht & Rawson's "Dyeing." In Large 8vo.
Handsome Cloth, Library Style. 16s. net.*

A DICTIONARY OF DYES, MORDANTS, & OTHER COMPOUNDS USED IN DYEING AND CALICO PRINTING.

*With Formulae, Properties, and Applications of the various substances described,
and concise directions for their Commercial Valuation,
and for the Detection of Adulterants.*

BY **CHRISTOPHER RAWSON, F.I.C., F.C.S.,**
Consulting Chemist to the Behar Indigo Planters' Association; Co-Author of "A Manual
of Dyeing;"

WALTER M. GARDNER, F.C.S.,
Head of the Department of Chemistry and Dyeing, Bradford Municipal Technical College;
Editor of the "Journ. Soc. Dyers and Colourists;"

AND **W. F. LAYCOCK, Ph.D., F.C.S.,**
Analytical and Consulting Chemist.

"Turn to the book as one may on any subject, or any substance in connection with the
trade, and a reference is sure to be found. The authors have apparently left nothing out.
Considering the immense amount of information, the book is a cheap one, and we trust it
will be widely appreciated."—*Textile Mercury.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

In Large 8vo, Handsome Cloth, with Numerous Illustrations. 9s. net.

TEXTILE FIBRES OF COMMERCE.

A HANDBOOK OF

The Occurrence, Distribution, Preparation, and Industrial Uses of the Animal, Vegetable, and Mineral Products used in Spinning and Weaving.

BY WILLIAM I. HANNAN,

Lecturer on Botany at the Ashton Municipal Technical School, Lecturer on Cotton Spinning at the Chorley Science and Art School, &c.

With Numerous Photo Engravings from Nature.

** The subjects discussed in this volume are, in order to facilitate reference, arranged in alphabetical order under their respective heads. The work may thus be regarded as a Dictionary on Textile Fibres. A feature of the work is the wealth of botanical description which accompanies the Section dealing with Vegetable Fibres.—*Publishers' Note.*

"USEFUL INFORMATION. . . . ADMIRABLE ILLUSTRATIONS. . . . The information is not easily attainable, and in its present convenient form will be valuable."—*Textile Recorder.*

TEXTILE PRINTING:

A PRACTICAL MANUAL.

Including the Processes Used in the Printing of COTTON, WOOLLEN, SILK, and HALF-SILK FABRICS.

By C. F. SEYMOUR ROTHWELL, F.C.S.,

Mem. Soc. of Chemical Industries; late Lecturer at the Municipal Technical School, Manchester.

In Large 8vo, with Illustrations and Printed Patterns. Price 21s.

GENERAL CONTENTS.—Introduction.—The Machinery Used in Textile Printing.—Thickeners and Mordants.—The Printing of Cotton Goods.—The Steam Style.—Colours Produced Directly on the Fibre.—Dyed Styles.—Padding Style.—Resist and Discharge Styles.—The Printing of Compound Colourings, &c.—The Printing of Woollen Goods.—The Printing of Silk Goods.—Practical Recipes for Printing.—Appendix.—Useful Tables.—Patterns.

"BY FAR THE BEST AND MOST PRACTICAL BOOK ON TEXTILE PRINTING which has yet been brought out, and will long remain the standard work on the subject. It is essentially practical in character."—*Textile Mercury.*

"THE MOST PRACTICAL MANUAL of TEXTILE PRINTING which has yet appeared. We have no hesitation in recommending it."—*The Textile Manufacturer.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

Large 8vo. Handsome Cloth. 12s. 6d.

BLEACHING & CALICO-PRINTING.

A Short Manual for Students and Practical Men.

BY GEORGE DUERR,

Director of the Bleaching, Dyeing, and Printing Department at the Accrington and Bacup Technical Schools; Chemist and Colourist at the Irwell Print Works.

ASSISTED BY WILLIAM TURNBULL

(of Turnbull & Stockdale, Limited).

With Illustrations and upwards of One Hundred Dyed and Printed Patterns designed specially to show various Stages of the Processes described.

GENERAL CONTENTS.—COTTON, Composition of; BLEACHING, New Processes; PRINTING, Hand-Block; Flat-Press Work; Machine Printing—MORDANTS—STYLES OF CALICO-PRINTING: The Dyed or Madder Style, Resist-Padded Style, Discharge and Extract Style, Chromed or Raised Colours, Insoluble Colours, &c.—Thickeners—Natural Organic Colouring Matters—Tannin Matters—Oils, Soaps, Solvents—Organic Acids—Salts—Mineral Colours—Coal Tar Colours—Dyeing—Water, Softening of—Theory of Colours—Weights and Measures, &c.

"When a READY WAY out of a difficulty is wanted, it is IN BOOKS LIKE THIS that it is found."—*Textile Recorder*.

"Mr. DUERR's work will be found MOST USEFUL. . . . The information given is of GREAT VALUE. . . . The Recipes are THOROUGHLY PRACTICAL."—*Textile Manufacturer*.

SECOND EDITION. Revised and Enlarged. With Numerous Illustrations. 4s. 6d.

GARMENT DYEING AND CLEANING.

A Practical Book for Practical Men.

BY GEORGE H. HURST, F.C.S.,

Member of the Society of Chemical Industry.

GENERAL CONTENTS.—Technology of the Textile Fibres—Garment Cleaning—Dyeing of Textile Fabrics—Bleaching—Finishing of Dyed and Cleaned Fabrics—Scouring and Dyeing of Skin Rugs and Mats—Cleaning and Dyeing of Feathers—Glove Cleaning and Dyeing—Straw Bleaching and Dyeing—Glossary of Drugs and Chemicals—Useful Tables.

"An UP-TO-DATE hand book has long been wanted, and Mr. Hurst has done nothing more complete than this. An important work, the more so that several of the branches of the craft here treated upon are almost entirely without English Manuals for the guidance of workers. The price brings it within the reach of all."—*Dyer and Calico-Printer*.

"Mr. Hurst's work DECIDEDLY FILLS A WANT . . . ought to be in the hands of EVERY GARMENT DYER and cleaner in the Kingdom"—*Textile Mercury*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

"Boys COULD NOT HAVE A MORE ALLURING INTRODUCTION to scientific pursuits than these charming-looking volumes."—Letter to the Publishers from the Headmaster of one of our great Public Schools.

OPEN-AIR STUDIES IN BOTANY:

SKETCHES OF BRITISH WILD FLOWERS
IN THEIR HOMES.

By R. LLOYD PRAEGER, B.A., M.R.I.A.

Illustrated by Drawings from Nature by S. Rosamond Praeger,
and Photographs by R. Welch.

Handsome Cloth, 7s. 6d. Gilt, for Presentation, 8s. 6d.

GENERAL CONTENTS.—A Daisy-Starred Pasture—Under the Hawthorns—By the River—Along the Shingle—A Fragrant Hedgerow—A Connemara Bog—Where the Samphire grows—A Flowery Meadow—Among the Corn (a Study in Weeds)—In the Home of the Alpines—A City Rubbish-Heap—Glossary.

"A FRESH AND STIMULATING book . . . should take a high place . . . The Illustrations are drawn with much skill."—*The Times*.

"BEAUTIFULLY ILLUSTRATED. . . . One of the MOST ACCURATE as well as INTERESTING books of the kind we have seen."—*Athenaeum*.

"Redolent with the scent of woodland and meadow."—*The Standard*.

OPEN-AIR STUDIES IN GEOLOGY:

An Introduction to Geology Out-of-doors.

By GRENVILLE A. J. COLE, F.G.S., M.R.I.A.,

Professor of Geology in the Royal College of Science for Ireland,
and Examiner in the University of London.

With 12 Full-Page Illustrations from Photographs. Cloth. 8s. 6d.

GENERAL CONTENTS.—The Materials of the Earth—A Mountain Hollow—Down the Valley—Along the Shore—Across the Plains—Dead Volcanoes—A Granite Highland—The Annals of the Earth—The Surrey Hills—The Folds of the Mountains.

"The FASCINATING 'OPEN-AIR STUDIES' of PROF. COLE give the subject a glow of ANIMATION . . . cannot fail to arouse keen interest in geology."—*Geological Magazine*.

"A CHARMING BOOK, beautifully illustrated."—*Athenaeum*.

Beautifully Illustrated. With a Frontispiece in Colours, and Numerous
Specially Drawn Plates by Charles Whymper.

OPEN-AIR STUDIES IN BIRD-LIFE:

SKETCHES OF BRITISH BIRDS IN THEIR HAUNTS.

By CHARLES DIXON.

The Spacious Air.—The Open Fields and Downs.—In the Hedgerows.—On Open Heath and Moor.—On the Mountains.—Amongst the Evergreens.—Cope and Woodland.—By Stream and Pool.—The Sandy Wastes and Mud-flats.—Sea-laved Rocks.—Birds of the Cities.—INDEX.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.